THE

POPULAR SCIENCE MONTHLY.

MARCH, 1884.

STUDENTS' ASSOCIATION FEB 22 1884

FROM MONER TO MAN.

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MAN has long been regarded not only as a compendium of the entire animal kingdom, but as an epitome of the universe—as Nature's short-hand expression of a long-continued history begun with the beginning condensation of the nebulæ, and still going on to the development of higher types of humanity. Nature's language is hieroglyphic, and for the correct interpretation of her occult characters a key is necessary. It is one of the many triumphs of modern science that she has found at least a partial key to this mysterious book, and it is to the unlocking of some of its secrets that your attention is invited on this occasion.

My subject—the development of the human body from a microscopic speck of living matter—is a vast one, and the attempt to condense its consideration into the space of a single hour can result, at best, in a little more than a bare outline; but even such an exposition, however imperfect, may perhaps be deemed justifiable as a means of inciting to further study, and it is in this hope that the task is undertaken.

In the earliest perceptible stage of its existence, the human being consists of a minute apparently homogeneous mass of living matter of the kind known, since the days of Von Mohl and Remak, as *protoplasm*. The word means simply the *first formative material*, or the material in which all plants and animals have their origin. That it is a fact of natural history, and not a mere figment of the scientific imagination, that all plants and animals originate in a common substance, is no longer denied. This great principle was, indeed, recog-

* Address delivered at the opening of the Twenty-ninth Annual Session.

nized by Harvey, and first expressed in his famous aphorism, "*Omne vivum ex ovo*"—an egg, whenever it occurs, consisting essentially of a minute globule of protoplasm.

What is the origin of this universal, white-of-egg-like material? As little is known of the history of the first production of protoplasm as of that of the elements—hydrogen, oxygen, nitrogen, carbon, etc., of which it is composed. So far as yet discovered, all protoplasm, whether vegetable or animal, is derived from pre-existing protoplasm. The spontaneous production of living matter from non-living materials has never been satisfactorily proved. The particular kind of protoplasm which we are about to consider—viz., the human germ—is the combined derivative of certain glands which exist in separate adult human beings who represent the opposite sexual polarities belonging to all except the lowest vegetable and animal types. At the earliest recognizable stage of his existence man may therefore be regarded, physiologically, as a secretion. Zoölogically, to what rank is he, then, entitled? The undeveloped human ovum, immediately after its fertilization, corresponds in structure to the lowest known order of the most simple class of animals, the *Protozoa*, which stand at the very foot of the zoölogical scale. To this most humble of all known living creatures Professor Haeckel has given the name of *Moner*, a word of the same origin as monad, and expressive of ultimate simplicity and primitiveness.

More simple even than the moner, however, is the *bathybius*, found on the deep-sea bottom, and described by Professor Huxley as consisting of an ill-defined mass of a slime-like material possessing all the properties of living protoplasm. Even granting with skeptics on this point that the existence of bathybius is not satisfactorily proved, we may nevertheless assert with confidence that, as the natural predecessor of the moner, it ought to exist, and will some time be discovered, just as certain unobserved heavenly bodies have been partially described and located by astronomers long before the telescope had penetrated the obscurity in which they were hidden.

Through the processes of nutrition, under the combined influences of growth and development, this non-nucleated mass of living protoplasm (the human ovum) acquires a nucleus; in other words, there appears at its center a minute speck of matter slightly more opaque than the surrounding matter. Differentiation has therefore begun; that is, a difference of parts has made its appearance. How does this nucleus (to which, in cell-physiology, so much importance is attached) differ from the surrounding matter which constitutes the bulk of the germ? Chemically, it is more active; it is believed to be the part where nutrition (the assimilation of new material) mainly takes place. Its greater chemical, and, therefore, nutritive activity, is shown by its deeper staining with coloring-matters, such as carmine and hæmatoxylin, and by the fact that, with the access of nutriment, fresh nu-

clei make their appearance. It undoubtedly contains a larger proportion of the nitrogenous matter which enters into the composition of all protoplasm, and, like the nuclei of other cells, a certain percentage of phosphorus. At this stage of its existence the germ (still microscopic) is represented in the zoölogical scale by the *Amœba*, which it closely resembles in structure, having thus ascended to the second round of the zoölogical ladder.

The amœba has received its full share of attention from biologists. Its physiological endowments are scarcely greater than those of the non-nucleated moner. Both are capable of effecting those exchanges of matter which constitute nutrition; both are capable of reproduction (a phase of nutrition); both have the power of changing their form by thrusting out portions of their mass (the so called "false-feet"), and of thus executing slight creeping movements. These little masses of protoplasm are also capable of responding to contact of other matter, thus exhibiting the rudiments of common sensation. What is the evidence of this capacity? How does the amœba manifest a sense of touch? When some substance, perhaps a smaller representative of its own species, floats against the surface of an amœba, the precocious bit of protoplasm responds to the salute by flowing around its victim, which is thereby inclosed within the body of its captor, and gradually appropriated as food. Probably the term "victim" is of doubtful application in this case, since the difference between eating and being eaten must be trifling. However that may be, the one improvises a stomach for the occasion, and digests the other with all the *nonchalance* of a Feejee-Islander. The human germ is, however, preserved from a similar indulgence in incipient cannibalism by its different environment—not the only period of its existence when it escapes evil-doing through lack of opportunity—for it receives its pabulum, ready prepared, from the blood of the mother, which is doubtless one of the conditions of its future higher development.

In this response to contact by movement on the part of the amœba, it exhibits the rudiments of both muscular and nervous action, since, under the influence of an external force or stimulus, a reflex movement is produced.

The next perceptible change in the evolution of the ovum is known as *segmentation*. This consists in an increase of its mass by duplication and reduplication; the single cell first acquires a second nucleus, and the surrounding protoplasm then separates into two masses, each having its own nucleus; this process is continued until the enveloping membrane contains a mass of cells, each like the original amœboid cell. From the resemblance of the ovum at this period to a mulberry, this is called the mulberry or *morula* stage of embryonic development. In the zoölogical scale, it corresponds to the *labyrinthula*, a little animal which consists of an aggregation of simple nucleated cells. From this multiplication of nuclei, which are regarded as the active centers

of nutrition, there must result an increased power of development and growth.

By the absorption of fluid from the maternal tissues in which it is imbedded and the accumulation of this fluid at the center of the mass, the cells of this mulberry-like body become crowded outward to the periphery, thus forming a lining for the membranous sac—i. e., the outer covering of the ovum—which incloses them, the entire globular mass now being about one twenty-fourth of an inch in diameter, and consisting of a structureless outer membrane lined with a layer of nucleated cells (the *blastoderm*), and filled with clear fluid. These lining cells multiply rapidly; the inner ones become larger, darker, and softer than the outer ones, and thus differentiation has again occurred —the lining having developed into two distinct layers. This is known as the *gastrula* stage of embryonic development. All animals, from sponges to man, pass through this phase, becoming first two and then three layered sacs; but, from this point, the different branches or subkingdoms diverge; and the next recognizable phase in the development of the human embryo is confined to vertebrates, with a single exception, the *ascidian*. The larval ascidian swims like a tadpole by means of a caudal appendage in which may be traced a rod-like body thought to be a rudimentary *chorda dorsalis*, since it resembles the embryonic structure which, in the perfect vertebrate, develops into the spinal column with its contained, highly endowed spinal cord. This, however, not only fails to develop but actually disappears in adult life, leaving the ascidian a simple invertebrate animal. But, whether the ascidian be a true connecting link between invertebrates and vertebrates, or, as suggested by Balfour, a reversion from the higher form, it serves equally to indicate a close relationship between these two great subdivisions of the animal kingdom.

Between the two layers of germinal cells which belong to the gastrula stage, a third layer is developed, and from these three layers (the *epiblast*, the *mesoblast*, and the *hypoblast*) all the tissues and organs of the body are derived. The inner layer (hypoblast) gives origin to the epithelial lining of the alimentary canal and to the various glands derived from it. From the outer layer (epiblast) are developed the brain and spinal cord, and the epidermis with its appendages and derivatives, including the organs of the special senses. From the middle layer (mesoblast) the various intermediate structures are produced. The remaining history of development is, therefore, the history of the differentiation of these three layers of the blastoderm (which alike consist of simple nucleated cells) into the various tissues and organs of the body. Accompanying this process there is a corresponding development of functions. As absorption and assimilation, so perfectly performed by these germinal cells, are, however, the fundamental facts in the nutrition of even the highest organisms, so also reaction in response to a stimulus, of which we have found even the moner and the

amœba to be capable, is the fundamental fact in the functions of the fully developed muscle, nerve, and brain of the highest organisms.

The embryon, in its condition of a three-layered sac, soon begins to show a slight bilateral symmetry, and a *chorda dorsalis* appears. Its rank, as a vertebrate, is thus established in the dawning of that important structure, a backbone.

Allusion has been made to the ascidian as introducing the vertebrate type. Whatever may be thought of the claims of this animal to so important a place in the genealogical tree, there can be little doubt about the position of the *amphioxus* with its dorsal cord distinct and persistent throughout life. Though classed, on this account, among vertebrates, it is singularly wanting in vertebrate characteristics, having neither heart nor brain in the true sense of these words. It is also destitute of limbs, even of the most rudimentary kind, such as are found in the very lowest fishes. In fact, it is distinctly neither vertebrate nor invertebrate, thus admirably filling the position of a connecting link between these two great subdivisions of the animal kingdom.

At the chordonian stage of its development, the human embryon is equally destitute of a true heart, brain, and limbs, thus corresponding to a sub-type of the vertebrates called by Haeckel, *Acrania*, of which the amphioxus is the best-known representative. There is, nevertheless, in this heartless, brainless, limbless, and almost shapeless mass of but slightly differentiated protoplasm, that wonderful impulse of evolution by which its destiny, as an individual of the highest organic rank, is assured.

Along the line of the *chorda dorsalis*, rudimentary nerve-centers and spinal vertebræ gradually appear, the embryon thus entering on a grade of development comparable to that of the lowest fishes, in which the spinal column is cartilaginous rather than bony.

The budding limbs resemble budding fins; arches similar to those which, in water-breathing animals, support the gills are seen; and the rudimentary lungs are mere air-bladders.

Next arises the *amnion* stage, so named from an important though temporary nutritive organ whose development begins at this period; it is an extension of the yolk-sac, and contains a highly nutritious fluid.

The gill-arches gradually disappear, developing into more advanced structures; the heart becomes subdivided into four chambers; the air-bladders give place to true lungs; and, with the complete formation of a placenta, the mammalian stage of development is fully established. The embryon is henceforth recognizable as belonging to the class mammalia, the highest of the vertebrates.

As the growing organism becomes more and more complex, its progress is more and more gradual. We have seen how the germ passes, almost at a single step, from the gastrula to the rudimentary

vertebrate stage; but, after the mammalian stage is reached, it moves with deliberation through various lower embryonic forms of the class mammalia, till the human type is fully developed. At birth even, differentiation is far from being complete; not only do the several human races differ materially in shape and size of skull and in weight of brain, but there are also wide possibilities of difference among individuals of the same race and even between members of the same family. Exceptional characters are not recognized in their cradles; on the contrary, growth and differentiation continue till full maturity is reached, lifting the inventor, the philosopher, and the creative genius as far above the average human being as the average human being is above the chimpanzee.

In order to illustrate the relations to each other of the different grades of animal life, Haeckel employs the figure of a tree, which is intended to exhibit the probable lines of evolution of the entire series of animal forms continued through vast geological periods; and it is a fact of the utmost significance that this tree serves equally well as an illustration of the plan and progress of *human embryonic development*, thus indicating that the life-history of every human embryo is a recapitulation, in brief, of the history of the development of the whole animal kingdom. The base of the trunk of this tree represents the lowest, i. e., the most simple of animal forms—those which the human germ so closely resembles after fertilization, before development has begun.

The roots of this tree have not been represented by Professor Haeckel; but the supposition that, like the roots of other trees, they are concealed in the inorganic crust of the earth, is necessary to the completeness not only of the figure, but of the theory which it is intended to illustrate; I have therefore ventured to make this addition in the copy of Haeckel's figure which is before you.*

Ascending by a single step, the lowest branches represent those organisms in which the first developmental change has occurred, the amœba, it will be remembered, showing its superiority to the moner in the possession of a *nucleus*.

From this point the trunk is carried upward through the various stages, giving off large branches which thereafter pursue separate paths of development in different directions. These groups, in their turn, subdivide; and while at each step the divergence is a gentle one, it nevertheless leads farther and farther away from the common type with which the process of differencing began; like the terminal twigs of any widely-branching tree which, though closely surrounded by other twigs, are far removed from the common trunk, and still more widely separated from those branches which have developed on the opposite side.

This tree is one which bears all manner of fruit; but, as all the

* The lecture was illustrated by drawings.

branches of a tree receive the life-supporting sap from a common trunk, so all living forms have a common origin in protoplasm with which the evolution of their life begins; the entire growth and development of the body consisting in the growth and differentiation of the protoplasm of which its tissues and organs are composed.

Observe how admirably the figure of a tree exhibits the supposed relationship between the various types of animals both extinct and living; indicating, not that each type has been derived directly from one immediately preceding it, either in time or in structural rank, but that various types have had a common ancestor from which, by development in different directions, all have more or less diverged; so that the relationship between man and the existing anthropoid apes, for example, is that of remote cousinship rather than of direct descent. The common stock is represented by the trunk of the tree; from this trunk, which rises higher and higher with each diverging offshoot, has sprung an immense variety of branches; and, at the very pinnacle of this magnificent structure, man appears—the crowning efflorescence of organic evolution.

The permanent types which represent these various phases of embryonic development show a progressively increasing differentiation from their environment. The moner and the amœba are almost as structureless as the water in which they are found, consisting of little more than water with a trace of albumen; in specific gravity, in temperature, in color, etc., the difference between these low organisms and their environment is slight. Compared with the differences—chemical, physical, and structural—between man and the invisible atmosphere in which he is submerged, the contrast in this particular is a striking one. This leads us to other considerations of still greater significance.

The true environment of any organism consists in as much of the external universe as that organism is capable of holding communication with; so that, as the life becomes higher, the environment also becomes more complex.

At the deep-sea bottom, where life is exhibited in its most simple grades, the temperature is unvarying; no light penetrates to those depths; a uniformity of conditions is thus preserved almost unbroken, and the adjustments necessary to the continuance of life under such circumstances are as trifling as the grade of life is simple.

By the greater complexity of the human organism as compared with other animals, man is brought into communication with and under the influence of a vastly increased variety of external conditions, mainly through the organs of the special senses and their intimate relations with a highly developed nervous system.

That without the eye and its connections with the brain we could have no consciousness of light is the merest commonplace of physiology; yet, could we realize the full meaning of this and other similar

facts, we should be near to an understanding of the difference between a high and a low organism; the life is high when there is a high degree of correspondence with a highly complex environment.

Poets have understood this principle better, perhaps, than physiologists.

"Who has no inward beauty none perceives,
Though all around is beautiful"—

says Wordsworth; and Coleridge—

". . . We receive but what we give;
And in our lives alone does Nature live!"

Emerson also embodies this whole philosophy in a single illustration: "The sea drowns both ship and sailor, like a grain of dust, and we call it fate; but let him learn to swim, let him trim his bark, and the water which drowned it will be cloven by it and will carry it like its own foam—a plume and a power."

When we remember that our environment consists, not only of the natural elements of earth and sky, reaching to the most distant star which communicates its vibrations to our atmosphere, but that it also includes other human beings with the influences which such an environment involves, we realize that, while physiology undoubtedly rests on chemistry and physics, it also includes psychology and reaches far toward sociology—sciences which involve the highest problems of our existence; and, though we find it impossible to sink our plummet to the depths of this ocean, or to send an arrow to the stars which gem the arching dome above, we may at least hope to gather a few shells on the shore of the one, and to intercept some gleams of light from those distant suns which fascinate by their very distance, and make glorious the night of our intellectual darkness even.

How, we next inquire, does the human embryo differ, at the progressive stages of its evolution, from the embryos of the various lower types which it successively resembles? Whence the impulse of development by which it rises from these lower levels to the human plane? In reply to these questions we can only refer to the principle of *heredity* which, though it imprints upon the germ no trace discoverable by any known test, unfailingly molds the plastic protoplasm into certain prescribed and prearranged forms, with their accompanying capacities and powers. The inherent forces by which one germ develops into an oak and another into a trailing vine, one into a mollusk and another into a man, are handed down from generation to generation, so that each plant and animal reproduces its own kind and not some other kind. This can not be regarded, however, as an exceptional fact; the production of the germ with all its hidden possibilities, like every other differentiation of matter, depends upon the general principle known as the *persistence of force;* and to deny that the power of development of any grade of life is inheritable is to deny the per-

sistence of force *—a doctrine which lies at the very foundation of the stately edifice of modern science.

What is there in the whole stupendous drama of evolution, as conceived by the most enthusiastic supporters of the hypothesis, more wonderful or more difficult of comprehension and acceptance than these facts of embryonic development at which we have briefly glanced?

By the simultaneous processes of growth and differentiation, by a gradual increase of complexity and heterogeneousness continued through a considerable period of time, a microscopic speck of apparently structureless protoplasm, undistinguishable by any known test from the germ of any other animal, develops into the most highly endowed organism of which we have any knowledge.

And through what agencies are these remarkable results accomplished? Besides the inherited impulse of growth and development already referred to, there is furnished to this germ a due supply of ready-prepared food; a certain uniform temperature is also secured to it until the time of birth. After that period, its environment becomes gradually more complex; but embryonic development does not differ essentially from the continued development of infancy, childhood, and youth, by which the adult state is reached. The minute speck of simple protoplasm which constitutes the human organism at the beginning of its career is as truly an independent individual as it ever becomes. At this, as at every subsequent stage of its existence, its life and growth and progress depend on the activities of its own tissues, brought into play by the influence of external forces. Then, as always, it receives food from its environment; while the appropriation and assimilation of this food, as well as the elimination of the products of disintegration and waste, are accomplished by means of the same processes of absorption, chemical combination and decomposition, which constitute nutrition at all periods of existence. The embryon lives its own life—a work which can not be delegated to another.

Our next inquiry is in regard to the forces manifested by living bodies. What are the relations between the highly developed varieties of protoplasm which constitute their different tissues and organs and the remarkable functions—muscular action, emotion, volition, etc. —peculiar to animal organisms?

This question will be best answered by means of a familiar illustration. By an appropriate combination of valves and pistons, of wheels and levers, and numerous other contrivances put together in strict conformity with the principles of mechanics, in which the most delicate allowances are made for unavoidable friction, and the attraction of gravitation is either annihilated by counterbalancing weights or turned to account as a source of power, a machine is constructed which strikingly illustrates the importance, not only of the particular

* See "Principles of Biology," Herbert Spencer, vol. ii.

character of the different parts of which it is composed, but of the *relations of these parts to each other*. The force operating such a machine may be derived from a simple fall of water, or from the oxidation of burning anthracite; but, although this may be the sole source of the actual energy expended, it is far from being the only factor concerned in the production of the special kind of work accomplished. The results are due to the transformations of this initial force into force of other kinds, the character of the work done depending on the peculiar construction of the machine—in other words, on the relations of its parts. Thus the expansive power of steam may be expended in the idle clapping of the lid of a tea-kettle, or in the driving of the piston in the engine of an ocean-steamer, according to the relations into which the steam is brought. Keeping this illustration in mind, we may perhaps attain to some conception of the meaning of a living organism, and wherein consist the differences in different organisms.

The life-processes are concerned in the building up of the tissues—that is, in the construction and constant repair of the mechanism out of materials supplied by food; coincident with this assimilation of new material, there is a corresponding accumulation of energy or force. The energies *liberated*, on the other hand, in the activities of muscle, nerve, brain, etc., come from the oxidation—the so-called waste—of these tissues; and (as in the machine) the results produced are due to the transformations of this initial force, derived from oxidation of the tissues, into other kinds of force, viz., those manifested by living animal organisms, the character of the work done depending (as in the illustration) on the particular construction of the mechanism concerned. In the operations of living organisms, not less than in those mechanisms whose motive power is derived from steam, not a known law of matter is violated, but all are wrought into a harmony so complete that the entire complex and heterogeneous structure acts as a unit.

Glancing in thought over the vast expanse of matter of which the universe consists, what has been the direction of the progress witnessed through the long ages since the beginning condensation of the nebulous masses in which our solar system is believed to have originated? The immense globes which whirl in repeated circles through the heavenly spaces, though bound together by the strongest and most subtile bonds, roll blindly on, forever unconscious of themselves and of one another. The lily of the field even, clothed in beauty though it be, and surrounded by the greater glories of earth and sky—the warm sunshine and green fields—has no conscious enjoyment of itself or of them; but as elements identical with those which compose these unconscious forms have combined and recombined in compounds of increasing complexity, as molecules have condensed and differentiated in the development of a higher kind of living matter, *consciousness* has dawned, and (mainly through the avenues of the special senses) *mind*

has developed. Each generation, heir to the endowments of all preceding ones, has added its increment of gain, and later generations—those which belong to the historic period—have begun their lives with a vast amount of inherited intelligence. There is sound philosophy in the statement once jocosely made, that the natives of a certain part of the country, remarkable for their intellectual activity, are born with a good common-school education. By far the greater part of our education is indeed born with us.

Increased refinements of emotion, clearer subtilties of thought—these are the directions which further development of the race must take; and the individual who experiences a hitherto unrealized emotion, or who grasps a new thought which corresponds with some never before observed fact or relation in the external world, is the seat and center of progress. In such minds, nature is undergoing a still higher evolution, and the colors of humanity are thus successively planted on hitherto unscaled summits.

COLLEGE ATHLETICS.

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II.—EVILS AND THEIR REMEDIES.

WITH regard to the evils of the present system of college athletics it must be remembered that the best system will not be free from all evil. No human system can be free from evil. Even the divine government of the world does not exclude the existence of evil. That the present system has evils is no valid argument against it, unless it can be shown either that these outweigh the good, or that some other practical system can be devised which shall have all the good with less of the evil of the present system.

1. One evil alleged against the present system is the excessive amount of time required for exercise under it. It is no doubt true that some students do give too much time to athletics. Some students also give too much time to study; yet that fact is not brought forward as a fatal argument against the college course of study. Of the two excesses—excess of study and excess of exercise—the dangerous pressure at present is toward excess of study. But, in point of fact, this evil of too much time given to athletics has been greatly exaggerated. The winter term is not open to the charge of excessive athletics. The athletes then training do not devote an average of more than an hour a day to exercise. Perhaps a few give an hour and a half. It would be safe to say that, counting all the time consumed, including the time

of exercise, the time used in going to and from the gymnasium, and the time used in dressing and undressing, it would not go beyond two hours per day, and in most cases would be less than that amount. So, to consider the question of excessive time, we must look at the fall and spring terms. In the fall, during days when afternoon recitations are held, the class nines do not spend more than two hours' time altogether, including both practice in the field and the time of going to and from practice. The same may be said of the Foot-ball and Lacrosse Teams. On Wednesday and Saturday afternoons the students give from two to three hours to practice. On these afternoons the match-games occur. They are prohibited on other days, except during examinations, at which time they are allowed on any day, provided no player is thereby prevented from attending his examination. The crews, also, in practice on the water and in going to and from their boats, spend two hours daily. On Wednesdays and Saturdays they use more time, but the practice is so arranged as not to interfere with recitations.

In the summer the same amount of time, daily, is given to practice, except that, when recitations cease and examinations begin, the University and Freshman Nines use more time. Even then that time will not average more than three hours per day. When match-games are played out of town, to the time of the game must be added the time used in travel to and from the scene of the match. In the season of 1882, of the games played during the time when recitations or examinations were being held, only five were played out of town by the Yale University Nine, though the men went out of town once or twice more but were prevented from playing by the rain. Of these five, three were played in New York city, which is only a little over two hours' ride from New Haven. Of the remaining two, neither needed more than thirty-six hours' absence from town.

The University Crew row only one race a year. The Foot-ball Elevens and the Lacrosse Team play a few games out of New Haven, but do not use in this way as much time as the Nine.

2. It is said that the excitement attendant on these sports distracts from study. It is true that the contests do furnish excitement for the students, but it is excitement of a healthy kind. Athletic sports do not divert so many from study as the theatre and billiards. Banish athletics, and you increase the attendance at the theatres and the saloons, where the temptations are greater, and the excitements less healthy than those of the ball-field and boat-race.

3. There is the evil of betting. This is not an evil peculiar to athletics. The men in college, who are in the habit of betting, would continue to bet on something else, if not a game were played nor a race rowed. Gambling would increase if the athletics were prohibited. Games and races in colleges do not create betting. They simply divert it from other channels.

4. Then there are the disorders consequent upon victories. These disorders are sometimes quite serious, but are by no means so serious as they are often represented to be. On the campus such disorders have never been more serious than some disorders taking place after the conferring of degrees. They have always been easily controlled. They have been avoided when the college authorities have given notice that a recurrence of them would imperil the existence of the athletic organizations, or annul the permission to play match-games. These disorders, then, can not be a necessary and inherent evil of athletics.

It may be replied that disorders consequent upon victories are not confined to the college campus. Indeed, to the minds of many candid men, the great disorders which bring dangerous disgrace to the present system of college athletics, and reflect upon college government as well, occur at the intercollegiate contests, when the athletes meet on neutral ground. Such men admit the advantages of the system. They would encourage it in the separate colleges, but would have it go no further. They would abolish intercollegiate contests altogether. But this action would do away with the very element (healthy rivalry between colleges) which is the most effective motive power and stimulus of the whole system. Without this element the system would go to pieces in many colleges. In others it would be miserably contracted and inefficient. For this evil a more general interest in the subject on the part of instructors and parents, and their more general attendance at the games, would easily suggest the remedies of a healthy and manifested public opinion and a judicious personal influence.

5. It is charged against athletics that they benefit the few, and that these few are those least requiring the exercise. One part of the charge can be appreciated—that few are benefited—these few being the members of the Crew, Nine, Eleven, and Lacrosse Teams of the university. These, with substitutes, amount to about fifty men. But it has been already shown that more men are induced to exercise than the actual membership of these organizations; and that the present system affects, in the matter of exercise, at least half of the undergraduate department.

The objection, that the men under training in the university organizations are the men least requiring the training, can be understood to be one of two propositions, viz., either that these men have naturally so much power or skill that they need not develop any more, or that they will cultivate their strength and nerve without being stimulated to do so by the workings of the present system. This would be like arguing that men of great mental gifts either do not need an education, or would get an education without any opportunities being provided for this purpose in a school or college system—a proposition which, however true in exceptional cases, taken as a gen-

eral statement no argument is required to prove absurd. Men of muscle do need exercise. Indeed, it may be said that they must have exercise. The more systematic such exercise is, the better their brains work, as observing instructors of such men will testify. The reason is plain. They enjoy better health. The men who suffer most from the confinement of student-life are the men of vigorous bodies. Their vital force is like a flame. It must be fed with oxygen. Many of them, without the capacity of self-control, and without the health which they gain by exercise under the present system of athletics, would never be able to graduate. Many others would graduate with impaired bodily powers, and others still as slaves to habits of dissipation.

6. It is said, again, that the system may develop men, but it only makes fine brutes of them, and sets before the college a false standard of excellence, viz., one entirely physical. It can not be said with truth that the standard is false. The standard of good scholarship remains, and many of the athletes take high rank in scholarship. The standard of good conduct remains. The students still respect their fellows who approach these standards, yet they think no worse of a man, but rather better of him, and rightly, too, if he be a thorough man, and have a manly body as well as a good mind and upright character. Other things being equal, the bright mind and good heart in a strong body are better than the same things in a weak body, because they can accomplish more in life.

It is further said that the applause bestowed upon some feat in any of the athletic contests helps to establish some boy in the conceit that he is a great man, because he can do such things, and that, therefore, study is of no further use to him. There may be such youths, but, whatever be their fate at other colleges, they seldom appear at the college with which the writer is connected, and when they do appear do not stay.

7. The evil of a general nature last to be considered is that of expense.

The expenses of the organizations which have special university representatives are only taken into account, since these are the organizations of which the evils have been so loudly proclaimed to the public. In the table given below (for Yale College), the "expenses" and "income" are the totals for both university and class clubs combined. For base-ball, foot-ball, and Lacrosse, the amounts in the column headed "Earned" are made up for the most part of gate-money taken at exhibition-games. For the boat clubs, of the amount put in the same column, $1,045.36 was the net result of a dramatic entertainment given by the students for the benefit of the university club. The balance was obtained from entrance and carriage fees at regattas, renting of lockers, and sale of boat.

CLUBS.	Expenses.	INCOME.			
		Total.	Balance from 1881.	Earned.	Subscribed.
Boat.....	$7,348.86	$7,426.52	$177.54	$1,322.11	$5,926.87
Base-ball...	6,863.38	7,254.15		5,457.15	1,797.00
Foot-ball...	2,689.80	2,792.36	$1,080.71	1,329.65	382.00
Lacrosse....	574.00	575.00		225.05	349.95
Total.....	$17,476.04	$18,048.03	$1,258.25	$8,333.96	$8,455.82

It will be observed that the total amount subscribed is less than half the expenses. Two hundred and ninety dollars of this sum was given by graduates. Deducting this, and considering that, according to the catalogue of 1881–'82, there were, in the undergraduate academical and scientific departments, seven hundred and eighty-six students, the cost (above earnings) of the present system averages only a little over ten dollars per man. As all departments are benefited by the system, the average ought to be taken for the whole university. There being in the university over one thousand men, the average cost per man would be considerably less than ten dollars. It will be said that part of the earnings come from the students, since they are the chief attendants at the game. This is true. Assuming that half the earnings come from the students (an amount probably in excess of the real amount), the average cost per man for the university will not be far from twelve dollars. Fifteen dollars per man would undoubtedly cover the whole cost of athletics throughout the year, counting not only the athletics represented in the table, but all other kinds as well. Certainly this does not seem an extravagant sum to pay for the benefits derived from the system. The writer believes that the expenses can be very much diminished. The tendency to unnecessary increase of expenses can certainly be diminished by measures hereafter noticed.

By the table, it will be seen that the subscriptions for base-ball and foot-ball were small in amount as compared with their earnings. It is generally believed, among students, that the university organizations of both these sports can be made self-supporting.

The evils already commented on are general. There are other so-called evils which are special—some peculiar to one kind of athletics, but not belonging to the others. One of these, charged against base-ball, is that the game brings the students into contact with "professionals." Whatever may be the extent of the evil in other colleges, at Yale it has not proved to be so great as to call for Faculty interference, or even to excite apprehension. All the evils, real or imaginary, connected with ball-playing, are reduced to a minimum when the students meet "professionals." They meet them simply for practice. Betting is, as a rule, precluded by the fact that the result is generally a foregone conclusion, and men bet on only doubtful issues. Off the field there is no more intercourse between the students and the "professionals" than is necessary to transact the business at-

tending the match. The professional nine are then generally represented by their business manager, and the students by the president or treasurer of their club. In the game one nine is in the field, while the members of the other are at the bases, or waiting for their turn at the bat. The "professionals" are under the strictest discipline, so that their presence does not invite or occasion dissipation in any form. Victories of college nines over "professionals" are not frequent, and are not attended by disorders on the campus.

But to some objectors the evil of "professionalism" in athletics includes more than playing with professional nines. The employment of professional "trainers" in preparing students for contests is, for some, the chief evil. Such trainers are looked upon as bad companions for our young men. It is contended that they undermine the morals of our students by their profanity and generally low talk. They are also supposed to give too high a standard of excellence for our amateur athletes, and thus to draw on too much of their time and strength, in the effort to make them conform to this standard. All these things may happen in some cases, but they do not happen frequently. Admitting, for the sake of argument, what is generally denied by the students, that for the past two years the crew has been coached by the professional oarsman who rigged their boats, his coaching would have brought him into personal contact with not more than a dozen men at the most, and for a time of only three or four weeks in the spring and summer. For a short time in the winter some of the candidates for the university nine have exercises in boxing with a trainer, in order to bring them into "condition" for the spring and summer work. There can hardly be more than fifteen such men.

The only other really professional training done has been done for those who go into track athletics. This training lasts for about six weeks, and is given to some fifteen or twenty men. A "professional" has sometimes accompanied the foot-ball team when they have played their great matches, but his office has not been to train the men, but to apply his skill to limbering stiffened joints and healing bruised muscles.

It is quite natural that students, when taking lessons of any kind, should prefer the best masters. Unfortunately, the best masters are not always the best men. That the pupils are, therefore, always led into bad courses by the example of their instructors does not follow. There is enough good sense in college students generally to dissociate good instruction from faults of character. The trainer seldom influences the student beyond the purpose of his training. The young man does not make a companion of his trainer, nor trust his morals to his direction. An easy cure for possible evils in this direction would be for the faculty of each college, troubled by vicious trainers, to forbid their students employing such men. An investigation, however, into the relations between such trainers and their pupils would show that

the pupils despise the lowness of the men quite as much as do the faculty themselves. Another and better remedy would be to select an amateur athlete from the graduates, educated as a physician, and give him a salaried office, with duties as general adviser and guardian of the athletic interests. Such a man, if properly qualified, would help the students to a safer and better physical development than they now get, and would, besides, soon drive away all trainers exercising improper influences among them.

In foot-ball there is no professional element. But it is charged against the game that there is danger in it to life and limb. Undoubtedly it is a rough sport, but year by year it is becoming less dangerous in consequence of the increasing strictness of the rules and the severity of the penalties against foul play. In the match-games these rules are generally so well observed that few accidents occur. In the games between Yale and Princeton, which have always been the most hotly contested, no man has been seriously hurt. It is a game which particularly requires courage, and is therefore a most manly game. It is like a battle with the danger not all left out, but a battle in which courage and self-possession not only secure victory but safety. With all its dangers it is less dangerous to the players than the confinement accompanying excess of study.

One great evil connected with athletics, and not generally receiving public notice or animadversion, is the excess of feeling between students of different colleges, occasioned by the intercollegiate contests. This excess of feeling seems akin to excessive class-feeling already noticed. It is partly due, no doubt, to the youthfulness of the parties. It is seldom entertained by the contestants. It is a strange fact that such feeling does not appear to exist between professional clubs, nor between professional and amateur clubs. In this matter, therefore, it would seem that the students might learn a good lesson from "professionals."

What the condition of the college would be without a system of athletics is a question already partly answered by what has been said in meeting the charges against the system. We can understand, also, the effect of abolishing the present system by calling to mind the disorders reported in colleges in which no such system is allowed to exist. The revolts against authority and the great disorders between classes now occur with the most frequency not at colleges which have the greatest number of students and the most extensive athletic organizations, but at the colleges in which the students either are not able or are not allowed to establish such organizations. The disorders which used to occur in New Haven thirty or even twenty-five years ago ought to convince any candid man that, however great the present evils of college-life are *with* athletics, the past evils *without* athletics were worse. On one occasion in those "good old times," in consequence of a conflict between students and town boys, a cannon was brought before the

college buildings to demolish them. The writer remembers another occasion when there was a collision between students and firemen, and one of the firemen was mortally wounded by a pistol-shot. That night the dormitories were bolted and barred and the students acted like a besieged party, and were making preparations for a possible fight the next day. In those same good old times there were more frequent disturbances between classes. There were snow-ball fights, too, on the campus, to the great destruction of window-glass. According to the testimony of men in the college in those days, drunkenness was more common. Certainly within the last twenty years the college sentiment with regard to intoxication has undergone a change for the better. Before that period a student given to this vice did not neces-

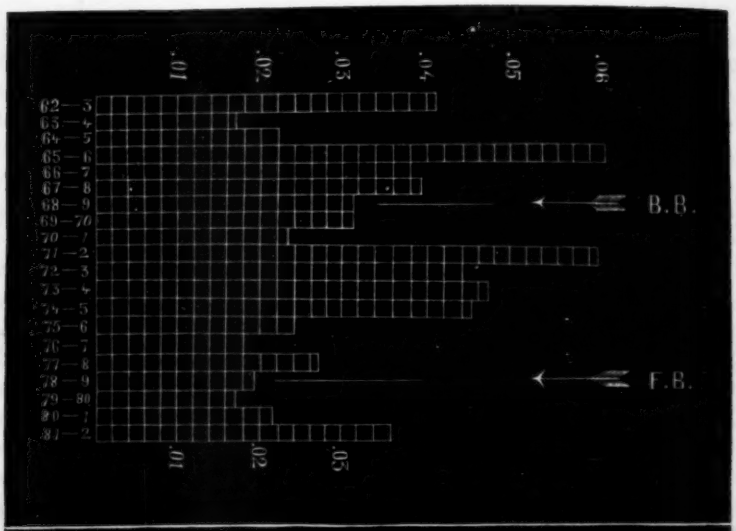

Fig. 1.

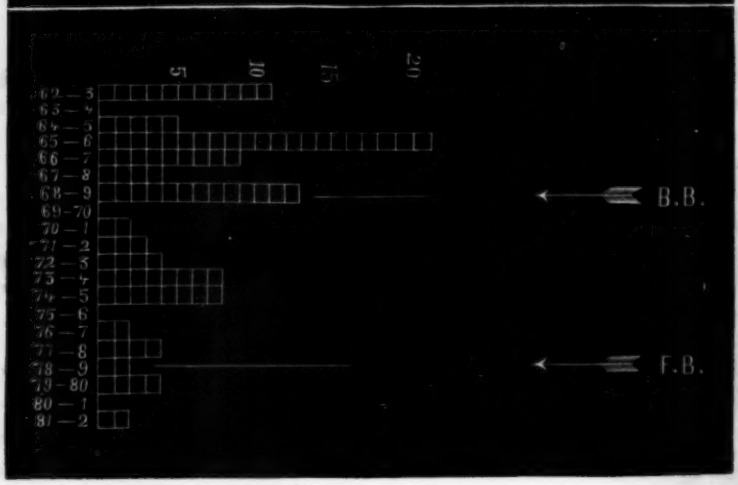

Fig. 2.

sarily lose caste among his fellows as he does at this day. The pressure of college opinion is against dissipation. It is absolutely necessary for the athletes to abstain from it. Being taught the evil effects of excesses upon their strong men, the university is not slow to see that intemperance is a wrong and an evil for all men.

As a contribution to this part of the discussion, the accompanying diagrams are offered, as bearing on the subject of disorders. The first diagram gives, for each year of the twenty college years from 1862–'63 to 1881–'82, the percentage of the number of men expelled and suspended from the Academical department of Yale College to the membership of that department. The numbers were taken from the Faculty records, and include expulsions for all cases of disorder; all dismissals and suspensions for disorders by day or by night; for drunkenness and for marks and irregularity. Each case counts as a unit without regard to the severity of the penalty. Had more weight been allowed to one case than another, it is not likely that the results would have been materially changed, as the severe punishments of expulsion and dismissal are infrequent. No account is taken of dismissals for scholarship, the writer for the present confining his investigations to the effects of athletics on college order. The percentages are arranged in vertical columns, one for each college year, the year being written under the column. Each square represents one fifth of one per cent (0·002). Thus, in 1862–'63, the cases of discipline were four and one tenth per cent of the total membership for that year. In the next year the cases of discipline were one and seven tenths per cent, etc. The average for the twenty years will be found to be about three per cent. For the first decade the average was a little more than three and six tenths per cent, and for the last decade a little less than two and four tenths per cent. Though a race between crews of Harvard and Yale was rowed as early as 1852, yet it was not until the summer of 1864 that the Harvard-Yale boat-race began to be the regular event which it has since continued to be. The first permission to play ball out of town was granted to the Yale Club in June, 1869, and the first permission to the Foot-ball Team was given in November, 1878. These permissions are indicated on the diagrams.

In the second diagram the expulsions, dismissals and suspensions for hazing, rushes, and attempted interference by members of one class with the liberty or property of members of another, are given by *numbers*. Each square represents one case of discipline. These cases, though already counted in forming Diagram No. 1, are represented in No. 2 by themselves, in order to make evident the fact that this particularly troublesome class of disorders is diminishing. The writer has already stated the reasons of his belief that the diminution of them is due in great measure to the influence of athletics.

In the opinion of the writer, the diagrams show that, whatever may be the public impression, the real facts, as evidenced by the Faculty

records, are, first, that the college disorders, as a whole, have not increased since the introduction of athletics ; and, second, that one class of disorders has sensibly diminished. Of course, other influences have contributed to bring about these results. Still, even if the claim in behalf of athletics of a special influence for good in this respect be not allowed, it can not be fairly said that the evil effects of the system are such as to overpower all the other good influences.

As to those evils which are capable of remedy, and of which the remedy has not been before expressed or implied, we will take up that of unnecessary expense. It has been before shown that the expense of the system is not enormous, considering the good done. But undoubtedly it is greater than it need be. Moreover, it will naturally tend to increase. Still, it is well to remember that, as the number of athletic organizations increases, the increased subscriptions demanded of the students begin to waken some of the thoughtful among them to wiser discrimination in their giving, and to a sharper watchfulness of the management of the associations to which they do give. Consequently, new care in the spending of money is required of each university organization, and a healthy suspicion on the part of the students is developing itself. In other words, each athletic interest begins to act as a check on the extravagance of the others. Still, money is inevitably wasted, in consequence of the inexperience of the young men. Each officer, as a rule, serves but a year, when he makes room for a new officer, who is as inexperienced as his predecessor. The experience gained each year might be made serviceable by associating with the incoming treasurer a permanent graduate treasurer. The vice-president might be elected to become president as soon as the year's service of the president expired, so that he would serve as vice-president one year and one year as president, his service thus extending over two years. It has also been proposed to consolidate the athletic interests under one salaried superintendent, who should be a graduate. The objection to this plan is that, though it might secure a more consistent and economic management, it would destroy the present healthy rivalry of the athletic interests, and relieve the students themselves of the responsibility of success or failure. Besides the changes suggested, a general auditing committee for all the interests should be formed consisting of graduates and undergraduates. At present, though the accounts of all the interests are published, yet nobody feels it his particular business to object to any one item. If a graduate finds fault, his complaint is not worth much, as only undergraduates are supposed to know the needs of to-day. A committee of both graduates and undergraduates could audit the accounts, and would be able to make suggestions which would be sure of a hearing. By such changes in the system and the economies which ought to result from them, field-sports, such as base-ball, foot-ball, and lacrosse, should be self-supporting. The income derived from gate-money should meet the expenses.

Since some very worthy people who believe in manly sports object to young men playing for money taken at the exhibition-games, it is necessary to say a word of explanation with regard to this feature of all ball-games. If field athletics are to continue, the expense of them must be met in one of two ways, either by gate-money or by subscription. Most young men prefer to give their money at the gate, and thus to pay for what they see. If a club knows that it is to spend only what it earns, it will be stimulated, first, to play as good a game as possible; and, secondly, to spend its earnings with prudence. It seems only just, too, that, if the public desire to see a good game, they should pay for the exhibition. The men work hard in practice, and are entitled to have their expenses paid. More than that they do not ask. They do not play for gain, but for honor. By their rules, they do not allow any man to be a member of their organizations who has earned money as a professional.

The evil of liability to strains and injuries in athletics can not be entirely obviated. It is well to bear in mind, at this point, the fact that even those who are not athletes do not, therefore, enjoy immunity from accidents. Yet, so far, according to the recollection of the writer, no regular member of a Yale Crew, Team, or Nine, has been permanently injured by participating in a race or match. Still, it is possible that a slight injury, to a person having organic weakness, might result in a fatal difficulty. Such an issue might be avoided by the requirement that every candidate for trial should be examined by a competent physician, and, in default of procuring a certificate of physical soundness, should be excluded from participation in athletic contests. Besides this, every candidate for a place in a crew should be debarred from entering a race unless he had mastered the art of swimming.

If, moreover, the Faculty of every college having a system of athletics would exert a sympathetic as well as a judicious oversight of the students interested in the system, they would find the young men quite willing to listen to friendly suggestions. If, also, the times of recitation were so arranged that a proper amount of time could be devoted to exercise without interference with study, more brain-work, and of better quality, would be secured than by the policy prevailing in some colleges, according to which, not only no encouragement is given to athletic sports, but, on the contrary, every obstacle is thrown in their way.

The college which neglects or ignores physical culture may send out scholars, but it will not educate forceful men. It will not be the living power which it might be. Truth is not to prevail by the dry light of intellect alone, but through the agency of good, wise, and strong men.

GREEN SUNS AND RED SUNSETS.

By W. H. LARRABEE.

THE whole world enjoyed, during the closing months of 1883 and through January, 1884, the spectacle of a succession of sunsets and sunrises marked by a brilliant, gorgeous red coloration. The phenomenon, if it had been only for a day or two, might not have excited any particular remark, for in the United States the sight of a brilliantly-colored sunset is not at all unusual; but when it was found to be continuous for months, and to extend to every part of the earth, the impression became nearly universal that something uncommon was going on in our atmosphere or in space. The phenomenon apparently reached its culmination about the 27th of November, when the western sky was illuminated for more than an hour after sunset by a lurid glow, as of some great conflagration; and in many places the public thought it actually was the mark of a fire, while in some towns fire-alarms were sounded. The phenomenon first began to excite attention in the Eastern States at about the time of its brightest manifestation, in the last days of November. It was, however, remarked on the Pacific coast about a week earlier; in Europe early in the month; and at points in the Indian and Pacific Oceans as early as September. Among the earliest published mentions of it were those from the islands of Rodrigues, Mauritius, and Seychelles, August 28th, Brazil, August 30th, New Ireland, September 1st, the Gold Coast, Africa, September 1st and 2d, and one that was made in connection with the observation of a "blue sun" at Trinidad, September 2d, when, after dark, says the report, "we thought there was a fire in the town, from the bright redness of the heavens." At Ongole, India, after the sun had set, green, "light yellow and orange appeared in the west, a very deep red remaining for more than an hour after sunset"; whereas under ordinary conditions all traces of color leave the sky in that latitude within half an hour after the sun disappears. Captain Rolland, of the French *Messageries* steamer Saghelien, passing from near King George's Sound, Australia, to the Island of Réunion, observed, from the 25th of September to the 12th of October, a red light around the sun, which became more pronounced at sunset, and persisted for a length of time after that hour in proportion as the ship was in a higher latitude. "The colored part of the sky, which was at times extremely lively, had, about a half-hour before sunset, a very considerable surface, extending to a distance of forty-five degrees from the sun." The same coloring was seen in the morning. A correspondent writing from Wailuku, Sandwich Islands, to the "Hawaiian Gazette" of October 3d, speaks of the "most extraordinary" sunsets they had been having for some time past, "fiery red,

spreading a lurid glare over all the heavens, and producing a most weird effect." The Attorney-General of West Australia wrote to Dr. J. W. Judd, October 27th, describing the same glow; and a letter from Umballah, India, October 30th, says: "There has been for some time a remarkable appearance in the sky every night. The sun goes down as usual and it gets nearly dark, and then a bright red and yellow and green and purple blaze comes in the sky and makes it lighter again. It is most uncanny, and makes one feel as if something out of the common was going to happen." The writer of this article has noticed from his own windows the interval of darkness between the setting of the sun and the appearance of the glow remarked in the letter.

The earliest observations of the glow in Europe appear to have been made about the 9th of November, after which time references to it and descriptions of it abound in the scientific and other journals. These descriptions agree with each other as to all essential features, and might be as well applied to the phenomenon as seen anywhere in the United States. The sky is generally spoken of as cloudless where the glow has appeared, although a few observers speak of light cirrus clouds floating in the air or passing over the sun or near it; and one observer at Ootacamund, India, mentions a green cloud that passed over the sun's disk, followed by a red one.

The red light is regarded by those who have paid most attention to the subject as associated with the blue or green sun which was observed in many parts of the East Indies early in September. It was noticed at Manila, in the Philippine Islands, on the 9th, when, during a "light dry mist," "the sun appeared colored green and diffusing over all the bodies it illuminated a strange and curious greenish hue, to the great terror of the islanders"; at Colombo, Ceylon, on the same day, when the sun, about forty minutes before setting, emerged from behind a cloud of a bright-green color. The whole disk was distinctly seen, and the light was so subdued that one could look steadily at it. The moon was also, to some extent, affected in the same way. A correspondent of the "Ceylon Observer," writing on September 12th from Puleadierakam, states that no light came from the sun, although it was visible, until nearly seven o'clock in the morning, and adds: "For the last four days, the sun rises in splendid green when visible—that is, about 10° from the horizon. As he advances he assumes a beautiful blue, resembling burning sulphur. When about 45° high, it is not possible to look at the sun with the naked eye; but, even when at the very zenith, the light is blue, varying from a pale blue early to a bright blue later on, almost similar to moonlight even at midday. Then, as he declines, the sun assumes the same changes, but *vice versa*. The heat is greatly modified, and there is nothing like the usual hot days of September. The moon, now visible in the afternoon, looks also tinged with blue after sunset, and as she declines, assumes a most fiery color at 30° from the zenith."

At Madras, India, Professor C. Michie Smith, of the Christian College, remarked the "perfectly rayless" and bright silvery-white color of the sun on the 9th of September. The same was noticed on the next day, but was succeeded, after the reappearance of the sun from behind a cloud, by a bright pea-green color. This peculiar color was again observed the next morning, and in the evening it "was a magnificent spectacle, and attracted the notice of every one. The silvery sheen was visible early in the afternoon, and the brightness of the sun rapidly faded, till by about five o'clock one could look at it directly without any difficulty. At this time there was a distinct tinge of green in the light when received on a sheet of white paper, while shadows were very prettily tinted with the complementary pink. As the sun sank toward the horizon the green became more and more strongly marked, and by 5.30 it appeared as a bright-green disk, with a sharp outline. In fact the definition was so good that a large spot (about 1′ long) was a conspicuous object to the naked eye." The green suns were also seen for several days about the 22d. The spectrum, which Dr. Smith carefully examined, "showed clearly that aqueous vapor played a large part in the phenomena, for all the atmospheric lines usually ascribed to that substance were very strongly developed. But in addition to this there was a very marked general absorption in the red." Abnormal electrical conditions of the atmosphere were noticed at this place in connection with the phenomenon. Of an earlier date than any of these observations is a notice of a "green sun," remarked at Panama on the 2d and 3d of September, the same day on which a blue sun and lurid sky were observed at Trinidad.

The appearance of the green color in the sun and in parts of the sky outside of the sphere of the red glow was also remarked in numerous observations made in Europe. In one of the earliest notices of the spectacle published in England, the writer says that at sunset "a very peculiar greenish and white opalescent haze appeared about the point of the sun's departure, and shone as if with a light of its own, near the horizon. The upper part of this pearly mist soon assumed a pink color, while the lower part was white, green, and greenish-yellow." Another observer, at Worcester, describes the blue of the sky as having been changed to green and the green as being speedily replaced by the ruddy tint; and again, in the morning, "the color of the sun changed to an exquisite emerald hue, staining the landscape, and investing houses, buildings, glazed windows, and greenhouses with a remarkably weird aspect." At sunset of the same day, "the crescent of the moon, being just above the fringe of red light, assumed a lively green hue, and continued to exhibit the novelty of an emerald crescent" for a quarter of an hour. At other places, we read of the contrast of the glow with "the pale greenish hue of the clear sky around"; of a crimson arch stretching from southeast to northeast, "with a very clear greenish-blue sky beneath it in the east," and be-

tween the arch and the western horizon "a sky of a bright silver-white color, which was so brilliant that it gave us quite a second daylight"; at another, of the sky nearer the zenith appearing "of a sea-green tint." The sea-green tint in the east was observed at Rome; and at Berlin, according to Herr Robert von Helmholtz, there was "a greenish sunset at 3.50, an unusually bright-red sky with flashes of light starting from southwest. An interesting physiological phenomenon which recalls 'Contrast-Farben' was there beautifully illustrated by some clouds, no longer reached by direct sunlight; they looked intensely green on the red sky." The whole phenomenon was exhibited, according to Mr. J. Addington Symonds, with remarkable intensity at Davos-Platz in the High Alps; and on one occasion "the whole north-eastern region of the heavens was at the same time of the most vivid golden-green — the peculiar green of chrysoprase and some highly-tinted beryls. Each tone of light, rose and green, was reflected on the long, broad basin of valley snow, the blending of both colors being of a strange, bewildering brilliancy." The sun, at this place, appeared through the day "surrounded by a luminous, slightly opalescent haze —not at all resembling halo or iridescence of vapor."

The red glow and the green sun are most likely due to a common cause. The same medium which will give by transmitted light a green color to objects viewed through it, will, by the universal law of the absorption and reflection of light, reflect the red rays. The close connection of the two phenomena may be regarded as real.

The spectacle must be due to some peculiar condition of our atmosphere, for, if it was produced by any cause outside of the atmosphere, it would have been visible in some form through the night, whereas its duration corresponded tolerably closely with that of ordinary twilight; the cause must have been co-extensive with the atmosphere, for the glow lasted as long as the twilight, if not longer. The manifestation was not auroral or electrical, for no auroras have been seen which could reasonably be associated with it, and no electrical disturbances have been mentioned in connection with it, except at Madras. Professor Michie Smith, of Madras, and Professor C. Piazzi Smyth, believe that it is the result of peculiar conditions of vapor in the air; but, while this might easily account for colors lasting a few days, it is difficult to suppose a peculiar accumulation and distribution of ordinary vapors enduring for so long a period. Nevertheless, Mr. Lockyer has seen the sun green through the steam of a steamboat; it has been seen green through the mist of the Simplon; and Mr. Henry Bedford, describing the summer sunset and sunrise just within the Arctic Circle in July, 1878, in an English magazine of that year, said: "The color brightens, and some small streaks of clouds grow brighter and brighter, until the sun—the GREEN sun—appears. A distant low range of rocks comes between us and its point of rising, and, as we glide on, an opening between them shows us the sun, a

bright emerald, as pure and brilliant as ever gem that glistened; again we lose it, and again an opening shows it to us in its own golden light; and then once more it is the bright green; and now it rises higher, clears the ridge, and is once more the golden orb." The Rev. G. H. Hopkins, of Cornwall, England, has observed that in a clear sky, as the disk of the sun sinks down beneath the horizontal line of the ocean, the parting ray is of a deep emerald green. The effect is not produced if there are clouds around the sun. Dr. F. A. Forel, of Morges, Switzerland, mentions as a fact confirmatory of the opinion that meteorological factors alone can not furnish a sufficient explanation of the phenomenon, that in Switzerland the glow, after having decreased subsequently to the 3d of December, attained a second maximum on the 24th and 25th of the month, when the atmospheric conditions were quite different from those which prevailed in the country at the time of the first maximum.

The hypothesis that the spectacle was caused by the presence in the atmosphere of a cloud of "cosmic dust," which the earth has encountered in its travels, has been advanced by several observers, and is supported by Mr. Proctor. Mr. Nordenskiöld and other men eminent in science have taught us to believe that a meteoric dust falling upon the earth from space plays a much more important part in terrestrial economy than we have been accustomed to suppose; and they have collected, in uninhabited countries and far away from any volcano, quantities of dust—little rounded particles of metallic compounds—unlike anything the earth is known to produce, and strikingly like what meteors of that size would be. Investigating whether an unusual quantity of such dust is now falling upon us, Mr. W. Mattieu Williams has found it in carefully selected snow from his garden. M. Émile Yung, of Geneva, has also found an extraordinary quantity of a similar dust in fresh snow that fell in the latter part of November and early in December on the steeple of the cathedral of Saint-Pierre, at "les Treize-Arbres," Mont Salève.

Numerous suggestions have been made that the phenomena are the result of the diffusion through the whole atmosphere of the entire earth of ashes and cinders from the eruption of the volcano of Krakatoa, in the Straits of Sunda, which took place on the 26th of August last. This theory has the support of Professor Lockyer and other eminent men of science, and there is much to be said in favor of it. The principal objections to it are summarized in a remark by Mr. Proctor, "that we should have to explain two incongruous circumstances: first, how the exceedingly fine matter ejected from Krakatoa could have so quickly reached the enormous height at which the matter producing the after-glow certainly was; and, secondly, how, having been able to traverse still air so readily one way, that matter failed to return as readily earthward under the attraction of gravity." It will not do to limit our ideas of the effect that may have followed the eruption of

Krakatoa by our knowledge of what has followed any other volcanic eruption; for the outburst at Krakatoa far exceeded in violence any event of the kind that is remembered in the history of man. Mr. W. J. Stillman, formerly United States consul in Crete, who has witnessed the explosions of two eruptions of the submarine volcano of Santorin, and has seen masses of rock weighing many tons thrown from a half a mile to a mile, and escaping gases expanding, after two seconds, into huge masses of cloud, at an elevation of from six to ten thousand feet, and then drifting away with the wind and dropping volcanic dust in its course, believes that on the enormously greater scale of the Krakatoa explosions the dust could have been thrown to the top of the atmosphere, there to drift over the whole earth; and he suggests that at such a height the distribution might be effected in twenty-four hours by a single revolution of the earth. Mr. Proctor's second difficulty is met by Messrs. Preece and William Crookes, who suggest that very finely divided particles of dust having an electrical charge of the same sign as that of the earth, may be kept suspended in the upper air for an indefinite period, by electrical repulsion; and Dr. Crookes adduces experiments showing how similar things have been done with electrified gold-leaf. Professor S. P. Langley contributes some interesting testimony on this point, which is based upon his observations on Mount Whitney, in 1881. On this mountain, from a height of twelve thousand feet, "we looked down," he says, "on what seemed a kind of level dust-ocean, invisible from below, but whose depth was six or seven thousand feet. . . . The color of the light reflected to us from this dust-ocean was clearly red, and it stretched as far as the eye could reach in every direction, although there was no special wind or local cause for it. It was evidently like the dust seen in mid-ocean from the Peak of Teneriffe—something present all the time, and a permanent ingredient in the earth's atmosphere. At our own great elevation the sky was of a remarkably deep violet, and it seemed at first as if no dust was present in this upper air, but in getting, just at noon, in the edge of the shadow of a range of cliffs which rose twelve hundred feet above us, the sky immediately took on a whitish hue. On scrutinizing this through the telescope, it was found to be due to myriads of the minutest dust-particles. . . . It is especially worth notice that, as far as such observations go, we have no doubt that the finer dust from the earth's surface is carried up to a surprising altitude. I speak here, not of the grosser dust-particles, but of those which are so fine as to be individually invisible, except under favorable circumstances, and which are so minute that they might be almost an unlimited time in settling to the ground, even if the atmosphere were to become perfectly quiet." Professor Langley thinks that the explosion of Krakatoa may have added millions of tons to the dust-envelope of the globe, and that the new contribution is not likely at once to fall to the surface again.

In illustration of this theory, we have the testimony of Captain Sir C. Fleming Stenhouse, who named the island, that after "Graham's Island" appeared in the Mediterranean in 1831, similar red sunsets to those the world has just been admiring were seen at Malta. A more striking record of a similar phenomenon is given in White's "Natural History of Selborne," Bohn's edition, page 300, where we read: "The summer of the year 1783 was an amazing and portentous one, and full of horrible phenomena; for besides the alarming meteors and tremendous thunder-storms that affrighted and distressed the different counties of this kingdom, the peculiar haze, or smoky fog, that prevailed for many weeks in this island, and in every part of Europe, and even beyond its limits, was a most extraordinary appearance, unlike anything known within the memory of man. By my journal I find that I had noticed this strange occurrence from June 23d to July 20th, inclusive, during which period the wind varied to every quarter, without making any alteration in the air. The sun, at noon, looked as black as a clouded moon, and shed a rust-colored ferruginous light on the ground and floors of rooms, but was particularly lurid and blood-colored at rising and setting. . . . The country people began to look with a superstitious awe at the red, lowering aspect of the sun; and, indeed, there was reason for the most enlightened person to be apprehensive, for all the while Calabria, and part of the Isle of Sicily, were torn and convulsed with earthquakes; and, about that juncture, a volcano sprang out of the sea on the coast of Norway." Cowper mentions the same phenomena in his "Task"; and Mrs. Somerville, in her "Physical Geography," traces their origin to the eruption of the volcano Skaptar, in Iceland, "which broke out May 8th, and continued to August, sending forth clouds of mingled dust and vapor, which spread over the whole of Northern Europe." It is stated in the "Annals of Philosophy," vol. ii, that the sun appeared of a blue color in England, in April, 1821; and it appears from other sources that a violent volcanic eruption had taken place in the Island of Bourbon in February of that year, and a destructive outbreak in Gunung Api in June of the previous year.

A curious counterpart to White's relation is given by Professor James Main Dixon of what he witnessed in Japan at the time of the eruption of Krakatoa. "During the two or three days at the end of August," he says, "we enjoyed fine, dry weather, but the sun was copper-colored and had no brightness. It was capital weather for traveling, but rather inexplicable. When we got to Nikko, the people came to us to inquire if some catastrophe were impending, for the appearance of the sun foreboded evil. We laughed at their fears, and assured them all was right. However, it seems that if the appearance of the sun foreboded no evil, it was a wonderful sign of the greatest earthquake and volcanic catastrophe on record. The fearful explosion of Krakatoa, in the Straits of Sunda, took place on August 26th; and

there seems little reason to doubt that the monsoon had carried the volcanic dust along with it, the dust obscuring the sun. The distance is nearly three thousand miles."

Dr. Budde, of Constantinople, was assured, when traveling in Southern Algeria in 1880, that the sun has a decidedly blue color when seen through the fine dust of a Sahara wind. Mr. Edward Whymper, remarking upon a metallic-green coloration of the moon, observed on some evenings in December, says that the peculiar hue recalled to him a similar appearance which he had witnessed in South America when the atmosphere was charged with volcanic dust; and he has described the colorings seen by his party under a cloud of ashes from Cotopaxi in language which would almost precisely apply to the diversified appearances that are the immediate subject of our discussion. Extremely brilliant colorations of the sky have been mentioned by several travelers as common spectacles in a particular tropical belt. Colonel Stuart Wortley, who spent the year 1862 in Southern Italy, in the study, by the aid of photography, of the formation of clouds, was struck with the unusual colors of the sunsets during and after the eruptions of Vesuvius with which that year was distinguished. Four years ago, while sailing in the Pacific, he was much impressed with the fact that "very frequently the whole vault of heaven was overspread with magnificent and glorious coloring, and that in the higher regions of the air colors were found that were never seen in the horizon or below a certain height." Inasmuch as this exceptional magnificence and peculiarity of coloring only occurs in certain latitudes and in well-defined belts, he suggests that, seen in the new light that is now cast on the subject, "the constant stream of volcanic matter thrown out by the great volcanoes in the mountain-ranges of South America, and possibly from elsewhere, form an almost permanent stratum of floating matter, carried in certain directions and kept in certain positions by alternating currents in the higher regions of the air, and that to this stratum of volcanic matter much of the exceptional coloring, found to be associated with sunrises and sunsets in portions of the Southern Pacific Ocean, is due." As an interesting coincidence in connection with this view may be noticed the extraordinary fact, to which Mr. Lockyer has called attention, that "before even the lower currents had time to carry the volcanic products to a region so near as India, an upper current from the east had taken them in a straight line *via* the Seychelles, Cape Coast Castle, Trinidad, and Panama, to Honolulu, in fact very nearly back again to the Straits of Sunda."

Very strong evidence in favor of the theory of the agency of volcanic dust has been derived from the examination of the sediment in freshly fallen snow at Madrid, Spain, on the 7th of December, and of the mineral matter deposited by a rain that fell at Wageningen, Holland, on the 13th of December. The sediment at Madrid, besides the ordinary atmospheric dust of the city, contained particles of what ap-

peared to be volcanic hypersthene, pyroxene, magnetic iron, and volcanic glass. At Wageningen, every drop of the rain that fell upon the windows left, when it dried up, a slight sediment of grayish-colored matter which was compared with original volcanic ash from Krakatoa that had been sent to the Agricultural Laboratory for analysis. Both the sediment and the volcanic ash were found to contain in common—1. Small, transparent, glassy particles; 2. Brownish, half-transparent, somewhat filamentous little staves; and, 3. Jet-black, sharp-edged, small grains resembling augite. These observations, say Messrs. Beyerinck and Van Dam, who made the analyses, "fortify us in our supposition that the ashes of Krakatoa have come down in Holland." On the 17th of November a fall of layers of gray and black dust took place at Storlvdal, Norway, and a fall of discolored rain near Worcester, England. Grayish sediments were found deposited on windows at Gainsborough and York, England, after a heavy rain on the 12th of December.

Mr. E. Douglas Archibald has suggested in "Nature" that, whether the cause of the phenomena be meteoric dust or volcanic ashes, the reflection arises from a definite stratum, and not merely from an atmosphere filled throughout with such dust. Professor Roujon, of Clermont, France, has also observed that two of the twilights, one following the other one day apart, "were so different in intensity as to provoke the supposition that the substance which produced them, at a great height, was not uniformly diffused, but moved in vast masses." This would serve to account for the variations that all must have observed in the brilliancy of the glow.

Mr. Edmund Clark has offered a suggestion upon which the theory that invokes the agency of aqueous vapor and the one which refers the manifestations to volcanic or meteoric dust may be combined, viz., that the dust may act as a nucleus for the condensation of any vapor that may exist at such a high level. The height of the mass of the matter producing the glow has been fixed by Miss Ley, of England, at thirteen miles.

THE ANCESTRY OF BIRDS.

By Professor GRANT ALLEN.

SEATED on the dry hill-side here, by the belted blue Mediterranean, I have picked up from the ground a bit of blanched and moldering bone, well cleaned to my hand by the unconscious friendliness of the busy ants; and looking closely at it I recognize it at once, with a sympathetic sigh, for the solid welded tail-piece of some departed British tourist swallow. He came here like ourselves, no doubt, to escape the terrors of an English winter: but among these pine-clad

Provençal summits some nameless calamity overtook him, from greedy kestrel or from native sportsman, and left him here, a sheer hulk, for the future contemplation of a wandering and lazy field-naturalist. Fit text, truly, for a sermon on the ancestry of birds; for this solid tail-bone of his tells more strangely than any other part of his whole anatomy the curious story of his evolution from some primitive lizard-like progenitor. Close by here, among the dry rosemary and large-leaved cistus by my side, a few weathered tips of naked basking limestone are peeping thirstily through the arid soil; and on one of these gray lichen-covered masses a motionless gray lizard sits sunning his limbs, in hue and spots just like the lichen itself, so that none but a sharp eye could detect his presence, or distinguish his little curling body from the jutting angles of the rock, to which it adapts itself with such marvelous accuracy. Only the restless sidelong glance from the quick upturned eye suffices to tell one that this is a living animal and not a piece of the lifeless stone on which it "rests like a shadow." A very snake the lizard looks in outline, with only a pair of sprawling fore-legs and a pair of sprawling hind-legs to distinguish him outwardly from his serpentine kin. Yet from some such lizard as this, my swallow and all other birds are ultimately descended; and from such a little creeping four-legged reptile science has to undertake the evolutionary pedigree of the powerful eagle or the broad-winged albatross.

Reptiles are at present a small and dying race. They have seen their best days. But in the great secondary age, as Tennyson graphically puts it, "A monstrous eft was of old the lord and master of earth." At the beginning of that time the mammals had not been developed at all; and even at its close they were but a feeble folk, represented only by weak creatures like the smaller pouched animals of Australia and Tasmania. Accordingly, during the secondary period, the reptiles had things everywhere pretty much their own way, ruling over the earth as absolutely as man and the mammals do now. Like all dominant types for the time being, they split up into many and various forms. In the sea, they became huge paddling enaliosaurians; on the dry land, they became great erect dinosaurians; in the air, they became terrible flying pterodactyls. For a vast epoch they inherited the earth; and then at last they began to fail, in competition with their own more developed descendants, the birds and mammals. One by one they died out before the face of the younger fauna, until at last only a few crocodiles and alligators, a few great snakes, and a few big turtles, remain among the wee skulking lizards and geckos to remind us of the enormous reptilian types that crowded the surface of the liassic oceans.

Long before the actual arrival of true birds upon the scene, however, sundry branches of the reptilian class had been gradually approximating to and foreshadowing the future flying things. Indeed, one

may say that at an early period the central reptilian stock, consisting of the long, lithe, four-legged forms like the lizards, still closely allied in shape to their primitive newt-like and eel-like ancestors, began to divide laterally into sundry important branches. Some of them lost their limbs and became serpents; others acquired bony body-coverings and became turtles; but the vast majority went off in one of two directions, either as fish-like sea-saurians, or as bird-like land-saurians. It is with this last division alone that we shall have largely to deal in tracing out the pedigree of our existing birds. Their fossil remains supply us with many connecting links which help us to bridge over the distance between the modern representatives of the two classes. It is true, none of these links can be said to occupy an exactly intermediate place between reptiles and birds; none of them can be regarded as forming an actual part of the ancestry of our own swallows and pigeons: they are rather closely related collateral members of the family than real factors in the central line of descent. But they at least serve to show that, at and before the period when true birds first appeared upon earth, many members of one great reptilian group had made immense advances in several distinct directions toward the perfected avian type.

Clearly, the first step toward the development of a bird must consist in acquiring a more or less upright habit: for the legs must be well differentiated into a large hind pair and a free fore pair, before the last can be further specialized into feathered wings; and the body must have acquired a forward poise before flying becomes a possible mode of locomotion. Such an upright habit is first foreshadowed in the larger-limbed and longer-legged lizards like the dinosaurians, which walked to some extent erect, and more particularly in some highly specialized reptiles like the iguanodon, which had large hind-legs and small fore-legs, and could walk or hop on the hind-legs alone, much after the fashion of a kangaroo, or still more of a jerboa or a chinchilla. Now, it is noticeable that the tendency to acquire the most rudimentary form of flying is common among animals of this semi-erect habit, especially when they frequent forests and jump about much from tree to tree. For example, among our modern mammals, the squirrels are a race much given to sitting on their hind-legs and using their paws as hands; while they are also much accustomed to jumping lightly from bough to bough: and some among them, the flying squirrels, have developed a sort of parachute consisting of an extensible skin between the fore and hind legs, which they use to break their fall in descending to the ground. Again, among the lower monkey-like animals, the so-called flying lemur or galeopithecus has hit upon an exactly similar plan; while, in the bats, a membrane which may be fairly called a wing has been evolved to a very high degree of perfection. Everywhere, the habit of living among trees or jumping from rocks tends to produce either parachute or wing-like organs;

and in our own time the tendency is very fully displayed among a large number of forestine mammals.

During the secondary ages, however, it was the reptiles which took to thus developing a rudimentary flying-mechanism. Even at the present day there are some modern lizards, the "flying-dragons" of popular natural history, which possess a parachute arrangement of the front ribs, and are so enabled to jump lightly from branch to branch, somewhat in the same manner as the flying-squirrels. But this is an independent and comparatively late development of a flying apparatus among the reptiles, quite distinct in character from those which were in vogue among the real and much more terrible flying-dragons of the liassic and oölitic age. Far the most remarkable of these predecessors of the true birds were the pterodactyls whose bones we still find in our English cliffs at Lyme Regis and Whitby; creatures with a large reptilian head, fierce jaws set with sharp-pointed teeth, and fore-arms prolonged into a great projecting finger so as to support a membranous wing or fold of skin, somewhat analogous to that of the bats. The pterodactyls do not stand anywhere in the regular line of descent toward the true birds; but they are interesting as showing that a general tendency then existed among the higher reptiles toward the development of a flying organ. In these frightful dragons, the organ of flight is formed by an immense prolongation of the last finger on each fore-leg, to a length about as great as that of the rest of the leg all put together. Between this long bony finger and the hind-leg there stretched, in all probability, a featherless wing like a bat's, by means of which the pterodactyl darted through the air and pounced down upon its cowering victims. As in birds, the bones were made very light, and filled with air instead of marrow; and all the other indications of the skeleton show that the creatures were specially designed for the function of flight. Imagine a cross between a vulture and a crocodile, and you have something like a vague mental picture of a pterodactyl.

But at the very time when the terrestrial reptilian type was branching out in one direction toward the ancestors of the pterodactyls, it was branching out in another direction toward the ancestors of the true birds. In the curious lithographic slate of Solenhofen we have preserved for us a great number of fossil forms with an extraordinary degree of perfection; and among these are several which help us on greatly from the reptilian to the avian structure. The lithographic slate is a member of the upper oölitic formation, and it is worked, as its name implies, for the purpose of producing stones for the process of lithography. But the same properties which make the slate in its present condition take so readily the impress of a letter or a sketch made it in its earlier condition take the impress of the various organisms imbedded as they fell in its soft mud. Even the forms and petals of early flowers washed down by floods into the half-formed mud-bank[1] have been thus preserved for us with wonderful minute-

ness. Most interesting of all for our present purpose, however, are the bones of contemporary reptiles and birds which this Nature-printing rock incloses for the behoof of modern naturalists. One such reptile, known as compsognathus, may be regarded as filling among its own class the place filled among existing mammals by the kangaroo. It was a rather swan-like, erect saurian, standing gracefully on its hind-paws, with its fore-legs free, and probably dragging its round tail behind it on the ground as a support to steady its gait. The neck was long and arched, and the head small and bird-like in shape; but the jaws are armed with sharp and powerful teeth, as in the pterodactyls. Altogether, compsognathus must have looked in outward appearance not at all unlike such birds as the auks and penguins, though its real structural affinities lie rather with the emus and cassowaries. The apteryx or kiwi of New Zealand, which is a bird that does not fly, because it has no wings worth mentioning to fly with, approaches even nearer in the combination of both points to this very bird-like oölitic reptile.

Even compsognathus himself, however, though very closely allied to the true birds, can not be held to stand as an actual point in the progressive pedigree, because in the very same Solenhofen slates we find a real feathered bird in person. Accordingly, as the two were thus contemporaries, the one could not possibly be the direct ancestor of the other. Nevertheless, it is certainly from some form very closely resembling compsognathus that the true birds are descended. We have only to suppose such a reptile to acquire forestine habits, and to begin jumping freely from tree to tree, in order to set up the series of changes by which a true bird might be produced. But the first historical bird of which we know anything, the archæopteryx of the Solenhofen slate, still remains in many points essentially a reptile. It is only bird-like in two main particulars; its possession of rudimentary wings and its possession of feathers. From the popular point of view, these two particulars are decisive in favor of its being considered a bird; but its anatomical structure is sufficient to make it at least half a reptile; and eminent authorities have differed (with their usual acrimony) as to whether it ought properly to be called a bird-like saurian or a lizard-like bird. There is nothing like a mere question of words such as this to set scientific men or theologians roundly by the ears for half a century together.

Archæopteryx, then, is just compsognathus provided with rude wings and feathers, but in most other respects a good lizard. Unlike all modern birds, it has a long tail composed of twenty separate vertebræ; and opposite each vertebra stand two stout quill-feathers, so that instead of forming a fan, as in our own pigeons and turkeys, they form a long pinnate series like the leaflets of yonder palm-branch. These feathers, like all others, show traces of their origin from the scales of lizards. Moreover, in the jaw are planted some small conical

teeth, the like of which of course exist in no living bird. The skeleton is for the most part reptilian; and, though the legs are bird-like, they are not much more so than those of compsognathus, an unmixed reptile. Even the wings are more like the fore-legs, and could only be used for flight by the aid of a side membrane. Accordingly, we may say that we have lithographed for us in archæopteryx a specimen of the intermediate state, when reptiles were just in the very act of passing into birds. The scales and protuberances on the body had already developed into feathers; the fore-legs had already developed into rude and imperfect wings, and the feet had become decidedly bird-like; but as yet there was only a very small breast-bone, the tail remained in internal structure like that of a lizard, the jaws still contained pointed teeth, and the wing ended in a three-toed hand, while flight was probably as rudimentary as in the flying-lemur and the flying-squirrel. Nowhere in the organic series has geology supplied us with a better missing link than this uncouth and half-formed creature, Nature's first tentative rough draft of the beautiful and exquisitely adapted modern birds.

Such an animal, once introduced, was sure to undergo further modification, to fit it more perfectly for its new sphere of action. In the first place, the tail was sure to grow shorter and shorter, by stress of natural selection, because a more fan-like organ would act better as a rudder to steer the flight than the long lizard-like tail of archæopteryx. In the second place, the general bony structure was sure to grow better adapted for flight, by the development of some such feature as the keeled breast-bone, and the general modification of the other parts (especially the wing) into better correspondence with their new function. At the same time, it must not be supposed that all intermediate birds would lose their reptilian features equally and symmetrically. Some for a time might retain one lizard-like peculiarity, say the teeth, and some might retain another, say sundry anatomical points in the structure of the skeleton. It was long indeed before the whole tribe of birds acquired the entire set of traits which we now regard as characteristic of their class. During the intervening period they kept varying in all directions, tentatively, if one may say so, and thus the early forms of birds differ far more among themselves than do any modern members of the feathered kingdom. In other words, when the full bird type was finally evolved, it proved so much better adapted to its airy mode of life than any other and earlier creature that it lived down not only the rude reptilian pterodactyls but also the simpler primeval forms of birds themselves: exactly as civilized European man is now living down not only the elephants and buffaloes but the red Indian and the Australian black fellow as well.

Some of the varying primeval forms have been preserved for us as fossils in the chalk deposits of the Western States, which are of course later in date than the oölitic slates of Solenhofen, where we find the

compsognathus and his cousin the archæopteryx. One of these first sketches, the ichthyornis, has a row of teeth in each jaw, and displays another strikingly early reptilian or fish-like peculiarity in the joints of its backbone, which are cup-shaped or hollow on either side, exactly like those of a cod. This strange bird must have resembled an emu in many respects, and it might easily have devoured the large ganoid fish of this period with its formidable jaws. Still more reptilian in some particulars is the hesperornis, also found in the Western American chalk. Hesperornis was a huge swimming ostrich, and it had pointed teeth like a crocodile's, set in a groove running down the jawbone. They were supported on stout fangs, in the same way as the teeth of its reptilian allies, the mosasaurians. Like the ostrich, hesperornis had a broad breast-bone, but this breast-bone was destitute of a keel, as is still the case in all the ostrich family. The wings were also very imperfect, like those of the cassowaries. In its tail, hesperornis resembled its predecessor, archæopteryx, so far as regards the lizard-like separateness of the vertebræ, except at the extreme end, where they were slightly massed together into the first resemblance of a plowshare-bone, such as the one I hold in my hand. Thus these two intermediate birds of the chalk period, though slightly more bird-like than their cousins of the oölitic age, still retained, each in its own way, many unmistakable relics of their descent from reptilian or almost amphibian ancestors. As usual, the further back we go, the more do we find all the lines converging toward a common center.

The primitive teeth died slowly and gradually out as time went on. In the still later eocene deposits of the London clay in the Isle of Sheppey, we find the remains of a true bird, known as odontopteryx, in which the teeth have entirely coalesced with the beak, and have assumed the form of bony projections. Strict biologists will tell us that these projections are not teeth at all, because true teeth are not bony in structure, and are developed from the skin of the gums. But such hair-splitting distinctions are of little value from the evolutionary point of view ; the really important fact to observe is this, that while hesperornis has teeth in a groove, reptile-fashion, ichthyornis has teeth in distinct sockets, mammal-fashion, and odontopteryx has them reduced to bony projections from the bill, in a fashion all its own, thus leading the way to modern birds, in which the teeth are wholly wanting and the bill alone remains. Indeed, among our existing kinds there are some which still keep up some dim memory of the odontopteryx stage ; for the merganser, a swimming fish-eating bird, has bony ridges on its bill, which help it to grasp its prey ; and the South American leaf-cutter has a double set of bony bosses on its beak and palate.

The most apparently distinctive feature of birds lies in the fact that they fly. It is this that gives them their feathers, their wings, and their peculiar bony structure. And yet, truism as such a state-

ment sounds, there are a great many birds that do not fly: and it is among these terrestrial or swimming kinds that we must look for the nearest modern approaches to the primitive bird type. From the very beginning, birds had to endure the fierce competition of the mammals, which had been developed at a slightly earlier period; and they have for the most part taken almost entirely to the air, where alone they possess a distinct superiority over their mammalian compeers. There are certain spots, however, where mammals have been unable to penetrate, as in oceanic islands; and there are certain other spots which were insulated for a long period from the great continents, so that they possessed none of the higher classes of mammals, as in the case of Australia, South America, New Zealand, and South Africa. In these districts, terrestrial birds had a chance which they had not in the great circumpolar land tract, now divided into two portions, North America on the west, and Asia and Europe on the east. It is in Australia and the southern extremities of America and Africa, therefore, that we must look for the most antiquated forms of birds still surviving in the world at the present day.

The decadent and now almost extinct order of struthious birds, to which ostriches and cassowaries belong, supplies us with the best examples of such antique forms. These birds are all distinguished from every other known species, except the transitional Solenhofen creature and a few other old types, by the fact that they have no keel to the flat breast-bone—a peculiarity which at once marks them out as not adapted for flight. Every one whose anatomical studies have been carried on as far as the carving of a chicken or a pheasant for dinner knows that the two halves of the breast are divided by a sharp keel or edge protruding from the breast-bone; but in the ostrich and their allies such a keel is wanting, and the breast-bone is rounded and blunt. At one time these flat-chested birds were widely distributed over the whole world; for they are found in fossil forms from China to Peru; but, as the mammalian race increased and multiplied and replenished the earth, only the best adapted keeled birds were able to hold their own against these four-legged competitors in the great continents. Thus the gigantic ostriches of the Isle of Sheppey and the great divers of the Western States died slowly out, leaving all their modern kindred to inhabit the less progressive southern hemisphere alone. Even there, the monstrous æpyornis, a huge, stalking, wingless bird, disappeared from Madagascar in the tertiary age, while the great moa of New Zealand, after living down to almost historical times, fell a victim at last to that very aggressive and hungry mammal, the Maori himself. This almost reduces the existing struthious types to three small and scattered colonies, in Australasia, South Africa, and South America respectively, though there are still probably a few ostriches left in some remote parts of the Asiatic Continent.

The Australian ostrich kind are in many respects the most archaic

and peculiar of all. Strangest among them is the kiwi or apteryx of New Zealand, that almost wholly wingless bird who may be seen any morning at the Zoo, gravely stalking up and down, like an important political prisoner, within the small inclosure to which tyrannical circumstances have temporarily confined him. The kiwi has feathers which closely resemble hair in texture, and his wings are so very rudimentary that they can only be properly observed at a *post-mortem* examination. His bones have no air-canals, and some of his internal anatomy is very abnormal. The cassowaries of the Papuan district are somewhat more bird-like in type, but they also preserve many antique features, especially in the relative smallness of the head and brain compared with the general size of the whole body. The Australian emus approach more closely to the true ostriches, and their feathers are far more feathery than those of the cassowary. In both these classes, however, the small and functionless wings are destitute of plumes, which are only represented by a few stiff, horny shafts. The true ostriches, including both the familiar African species and the South American rheas, have real wings with real feathers in them, though they can only use them to aid them in running, and not for the purpose of flight. They are therefore the most bird-like of their order, with small wings and very feathery plumes. We may fairly regard all these keelless and often almost wingless birds—the kiwis, cassowaries, emus, and ostriches—as the last survivors of a very ancient group, immediately descended from ancestors not unlike the toothed hesperornis, and never forced by circumstances to develop into the full avian type represented by the swallows, hawks, and herons. All of them are strictly terrestrial in their habits; none of them can fly in even the slightest degree; and the feathers of the most developed among them invariably lack the tiny barbules or small hooks which bind together the cross-barbs in the feathers of the flying bird, so as to form a compact and resisting blade. It is this looseness of the cross-barbs which gives ostrich-plumes their light and fluffy appearance; while, pushed to an extreme in the cassowary and the kiwi, it makes the plumage of those ugly birds approximate in character to the hair of mammals. Though from the human and decorative point of view we may admire the fluffiness of ostrich-plumes, it is obvious that, looked upon as a question of relative development, such loose, floating barbs are far less advanced in type than the firm and tightly interlocked quill-feathers of a goose or a raven, with which alone sustained flight is possible.

Except in such isolated countries where higher mammals do not, or did not till lately, exist, the power of flight, once acquired, was sure to be developed in a high degree. For the possession of feathers gives birds an advantage in this respect which enables even the little sparrows to hold their own in the midst of our crowded cities. Hence all other modern birds, except these lingering, ostrich-like creatures,

have keeled breast-bones, which imply their descent from forms adapted to true flight. They are linked to the ostriches, however, and therefore to the still earlier toothed ancestral types, by the South American tinamous, which are intermediate in various anatomical points (too intricate for a lazy man to go into here and now), between the two classes. Put briefly, one may say that these partridge-like Paraguayan birds are ostriches in the bones of their head, but game-birds in those of the breast and body. This line of descent seems to lead us up directly toward the cocks and hens, the pheasants, and the other scrapers. There are more marks of a primitive organization, however, among the penguins, which are almost wingless swimming birds, belonging nearly to the same class as the ducks and geese ; and we have reason otherwise to consider the penguins a very early form, since fowls resembling them in many particulars have been unearthed in the upper greensand. Here the wings are reduced to small rudiments, covered with bristly, scale-like feathers, and so rigid that they can be only moved in the mass like fins by a single joint at the base. They are used, in fact, exactly in the same way as the flappers in seals, to assist the bird in diving. The habitual erect attitude of the penguins strongly recalls that of their reptilian ally, compsognathus. From such an incomplete form as this, the gap is not great to the equally erect auks, the guillemots, the grebes, and other web-footed divers, which have short, pointed wings with true quills, but without any extended power of flight. Some species, indeed, can not fly at all, though the puffins and many other kinds can steer their way through the air with comparative ease. Thence to the cormorants, gulls, and ducks the transitions are slight and easy. We are thus led insensibly from almost wingless erect birds, like the penguins, through winged, but mainly swimming forms like the auks and divers, to creatures with such marvelous powers of flight as the frigate-birds, the petrels, and the albatrosses, which pass almost their whole life upon the wing. It must be remembered, however, that in this line of descent the comparatively wingless forms must be regarded as somewhat degenerate representatives of flying ancestors ; for the presence of a keeled breast-bone almost conclusively proves hereditary connection with fully-winged progenitors.

By far the greater number of modern birds belong to the still more strictly aërial orders of the perchers, the peckers, and the birds of prey. In almost all these cases, the power of flight is highly developed, and the bird type reaches its highest ideal point of typical excellence. Among the perchers, this perfection of form is best seen in the swallows, whose ceaseless and graceful curved evolutions everybody has seen with his own eyes ; while among tropical varieties of the same type the birds-of-paradise, the sun-birds, and the orioles are the most conspicuous. Among the peckers, our own swifts closely simulate the swallow type, while their American relatives, the hum-

ming birds, in spite of their small size, possess a power of rapid flitting and of lightly poising themselves in front of flowers which makes them in some ways the very fullest existing embodiment of the avian ideal. To the same order belong also those most intelligent of all birds, the parrots, whose large heads and crafty eyes mark them at once as the opposite pole from the small-browed, dull-eyed, stupid cassowaries. With them must be ranked the toucans, the barbets, the king-fishers, the trogons, and whole hosts of other beautiful southern creatures, among which the feathers have been variously modified into the most exquisite ornamental devices. As for the birds of prey, the eagles, vultures, falcons, hawks, owls, and ospreys must suffice by way of example.

Even among these central groups of birds, which have varied most and developed farthest from the primitive reptilian character, there are many kinds which retain here and there some small and isolated peculiarities of the ancestral forms. For example, among the duck-like birds, as we have already seen, a single group, that of the mergansers, still keeps up some faint memory of the original sharp teeth in the shape of a few horny projections along the edge of the beak. The tooth-billed pigeon of Samoa, a close relation of that early and extinct form the dodo, has also some rudiments of horny teeth; and the South American leaf-cutters, a primitive set of songless perchers, possess somewhat similar relics of the lost fangs. So, too, our earliest known bird, the archæopteryx, had three free claws on its fore-limb or undeveloped wing; and traces of such claws turn up in sundry unconnected birds even now, no doubt by reversion to the almost forgotten ancestral type. In all modern birds, one of the three fingers which make up the pinion still remains free; and in some species this finger supports an evident claw, sometimes used as a spur for the purpose of fighting. In many thrushes a rudiment of this claw may be perceived in the shape of a small tubercle or knob at the end of the wing, thus pointing back directly to some remote four-footed and claw-bearing reptilian ancestor. Several plovers have spurs, and so has the spur-winged goose; while the horned screamer has two on each wing, which he uses with great effect in battling with his rivals. The Australian brush-turkeys have also the rudiment or last relic of a primitive pinion-claw.

There is another way in which modern birds still partially recall the peculiarities of their reptilian ancestors, and that is in the course of their individual development within the egg. No adult existing bird has all the bones of the tail distinct and separate, like those of the archæopteryx; the last joints are all firmly welded together into a solid expanded piece, known from its queer shape as a plowshare-bone, such as the one which I am holding in my hand as the text for this discourse. The use of the plowshare-bone is to support the fan-like quill-feathers of the tail, and also to shelter the oil-

glands with whose contents the birds preen and dress their shining plumage, to secure them against the evil effects of damp or rain. But, while the young chick is in the egg, all its tail-bones still remain separate, as in the ancestral, lizard-like bird and the still earlier ancestral lizard; it is only as the development of the embryo progresses that they become firmly united, as in modern forms. In other words, every young bird begins forming its tail as if it meant to be an archæopteryx, and only afterward so far changes its mind as to become a crow or a sparrow. Similarly, no adult existing bird has true teeth; but the young of certain parrots show in the egg a set of peculiar little swellings inside the jaw, known as dental papillæ, and commonly found as the first stage of teeth in other animals. Moreover, these swellings are actually covered by a thin coat of dentine, the material of which true teeth are made. So here again the young parrot begins its development as though it meant to start a set of conical fangs in its jaw, like those of the archæopteryx, but afterward changes its mind and contents itself with a bill instead. Such symptoms as these point back surely though remotely to a far-distant reptilian ancestry.

It is worth while noting, too, that the links which bind the birds to the reptiles bind them also in part to the lower mammals. For the lowest existing mammal is that curious Australian creature known to the rough-and-ready classification of the colonists as the water-mole, and rejoicing in the various scientific *aliases* of the ornithorhynchus and the duck-billed platypus. Unsophisticated English people know the animal best, however, as "the beast with a bill." Now, there are many close resemblances between this strange Australian burrower, on the one hand, and such antiquated forms of birds as the New Zealand kiwi, on the other. In many particulars, too, the water-mole recalls the structure of reptiles, and especially of the ichthyosaurus. In short, it is at once the most bird-like and the most reptile-like of mammals. Hence we may fairly conclude that birds and mammals are both descended by divergent lines from a single common reptilian ancestry. For, on the one hand, the kiwi, an early type of nocturnal bird, preserved for us in isolated New Zealand, has some marked reptilian and mammalian affinities, not only in the external character of its hair-like feathers, but also in the more important structural points of its diaphragm, its movable vertebræ, and its keelless breast-bone, which are questions rather for the professed anatomist than for mere idle loungers basking lazily in the sun on a Provençal hill-side. And, on the other hand, the ornithorhynchus, an early type of burrowing aquatic mammal, preserved for us in isolated Australia, has marked reptilian affinities in its bony structure, and in the teeth implanted on its tongue; while it has also marked resemblances to the ducks and other swimming birds in the external features of its horny bill and webbed feet, besides being still more closely related to them in many of its less obvious anatomical peculiarities.

Birds, then, may be roughly described as reptiles with feathers. Professor Huxley was the first to see the real closeness of the connection between the two groups, and to unite them under a common name as Sauropsida. Strictly speaking, the only constant difference between them, the only one distinctive character of birds as a class, is the possession of feathers; and, if, like uncompromising Karl Vogt, we insist upon calling archæopteryx a reptile, because of its anatomical peculiarities, even this solitary distinction must vanish utterly, leaving us no point of difference at all between the two classes. It must be remembered, of course, that all the other characters which we always have in our mind as part of the abstract idea of a bird are either not constant or not peculiar to birds alone. For instance, we usually think of a bird as a flying animal; but then, on the one hand, many birds, such as the ostriches, kiwis, penguins, and dodos, do not or did not fly at all; and, on the other hand, many other creatures, such as the bats, flying-squirrels, flying-lemurs, pterodactyls, dragon-lizards, and butterflies, do or did once fly just as much as the birds. So with their other peculiarities: their habit of laying eggs descends to them from fish and reptiles; their nest-building propensities, which are wanting in some birds, are found in the Australian water-mole, in field-mice, and even in stickleback; and their horny bill, which is almost confined to them, nevertheless occurs again in the ornithorhynchus and in many turtles. In short, every other apparently distinctive point about birds except the possession of feathers either breaks down on examination or else descends to them directly from early unbird-like ancestors. And the first feathered creature of which we know anything, archæopteryx, was at least as much of a reptile as of a bird.—*Longman's Magazine.*

MEXICO AND ITS ANTIQUITIES.*

THE Mexican Republic extends from the fifteenth to the thirtieth degree of north latitude, and embraces an area of about 750,000 square miles. It is traversed by the continuation of the Cordillera of South America, here called the Sierra Madre, which trends northwesterly from the Isthmus of Tehuantepec, and varies in height from a moderate elevation in the southern States of Chiapas and Oaxaca to a mean height in the nineteenth degree of latitude of 9,000 feet, with the peaks of Orizaba and Popocatepetl—"the culminating point of North America"—rising to the elevations of 17,200 and 17,720 feet respectively. On the parallel of 21°, the Cordillera becomes very wide and divides itself into three ranges: one running eastwardly to Saltillo

* Appletons' Guide to Mexico. By Alfred R. Conkling, LL. B., Ph. B. With Railway Map and Illustrations. New York: D. Appleton & Co. Pp. 378.

and Monterey; one traversing the States of Jalisco and Sinaloa, and subsiding in Northern Sonora; and a central ridge extending through the States of Durango and Chihuahua, and forming the water-shed of the northern table-land. This range decreases in elevation going northward. Four peaks—Popocatepetl, Iztaccihuatl, Orizaba, and the Nevada de Toluca—rise above 15,000 feet, and three others—the Cofre de Perote, Ajusco, and the volcano of Colima—above 11,000 feet.

FIG. 1.—INDIAN HUT IN THE TIERRA CALIENTE.

The country is divided into three zones: the *tierra caliente*, or hot land, bordering the coast of either sea for from forty to seventy miles inland; the *tierra templada*, or temperate land; and the *tierra fria*, or cold land. About one half the surface of the country lies in the latter zone, while the remainder of the republic is almost equally divided between the temperate and hot regions. The country consists for the most part of a plateau, having an average height of about 6,000 feet above the level of the sea, which extends from the frontier of the United States to the Isthmus of Tehuantepec, and is about 350 miles wide in the latitude of the capital. But few of the rivers are navigable, and the longest of them, the Rio de Santiago, is only 542 miles long. The numerous lakes on the plateau are mostly shallow lagoons, the mere remains of large basins of water that formerly existed, and without outlet, and therefore filled with salt water. After the lagoon of Terminos, on the coast of the Gulf of Campeachy, which is really an arm of the sea, the largest lakes are the Lake of Chapala, in the State of Jalisco, and Lakes Patzcuaro and Cuitzco. The country enjoys a variety of climates, of which those of the temperate and cold regions are tolerably uniform. The rainy season generally occurs in

the summer, but at other times the air of the plateau is inconveniently dry.

A large part of the country is overlaid by the igneous rocks, of which trachyte, feldspar, porphyry, and amygdaloid basalt, are of most frequent occurrence. In the Sierra Madre the metamorphic rocks are common. Limestone is extensively quarried at Orizaba, and constitutes the greater part of the eastern branch of the Cordillera between San Luis Potosi and Monterey. The Cordillera, from Chihuahua on the north to Oaxaca on the south, contains very extensive deposits of gold, silver, iron, copper, and lead; and zinc, mercury, tin, platinum, and coal occur in a few places. The argentiferous veins constitute the principal part of the mineral wealth of the country. The silver occurs generally in the form of sulphides, in gangues of quartz, frequently in the metamorphic clay-slate, but sometimes in porphyry, as at Real del Monte, or in talcose slate, as in some mines at Guanajuato. Among the most remarkable mineral veins of the continent, after the Comstock lode, are the *Veta Madre* of Guanajuato and the *Veta Grande* of Zacatecas, which have been worked for about three hundred years.

The next most important deposits are the immense beds of iron, chiefly in the form of the magnetite and hematite ores. The well-known *Cerro del Mercado*, in the State of Durango, has been estimated to contain sixty million cubic yards of iron-ore, which have a weight of five billion quintals, and give, according to an analysis by Mr. M. H. Borje, of Philadelphia, sixty-six per cent of pure metal. Lead-ores are abundant; copper is mined at various places; oxide of tin is found in veins and alluvial beds at Durango. Mercury occurs as cinnabar in several States; and zinc-ores, with platinum, antimony, cobalt, and nickel, in not large quantities, are found in Chihuahua. The principal coal-beds are in the States of Oaxaca, Vera Cruz, Mexico, Puebla, Nuevo Leon, Tamaulipas, and Sonora. The anthracite-bed recently discovered at Barranca, on the Yaqui River in Sonora, is probably the largest and richest deposit of coal in the republic. Lignite, or brown coal, occurs in many places, but is not used to any great extent. The demand for coal is, so far, much greater than the supply accessible to the railroads. Mining is still conducted by working on the old Mexican plan, and this system has been found, under existing circumstances, to be more economical and profitable than a system in which modern and improved methods are applied.

Some of the oldest mines in Mexico, many of which were worked before the Spanish conquest, are at Pachuca, in the State of Hidalgo. There are about one hundred and fifty of them, seventy-five of which are in the Real del Monte, affording an ore composed mainly of blackish silver sulphides. The ore is worked here, as at Guanajuato, by the *patio* process, which is illustrated in the accompanying view. It is first crushed by a revolving stone wheel, iron-tired, in a pit, at the

center of which is a sieve through which the finer pieces are shoveled into a vault below. These pieces are then carried to the *arrastras*, flat stones of hard rock kept revolving in a large tub half-filled with water, where they are in twenty-four hours ground to a fine powder.

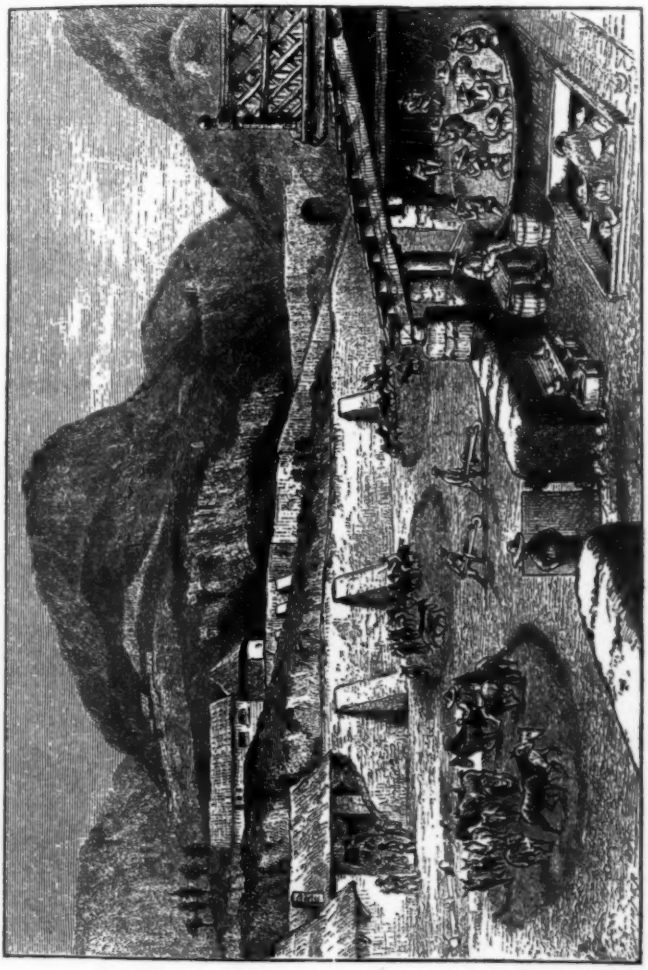

FIG. 2.—SILVER MILL AT PACHUCA.

The pulverized ore, called *lama*, is next carried to the *patío*, a court-yard paved with large flat stones, where it is allowed to accumulate to a depth of about two feet. The muddy mass is then mixed with *magistral*, or blue vitriol, salt, and quicksilver, and the whole, now called *torta*, is thoroughly stirred together by the trampling of mules. This process is kept up for seven hours daily, for from two to four weeks, according to the quality of the ore. The *torta* is then carried to the *lavaderos*, or large cisterns, where it is washed and stirred by means of

revolving sticks. The silvery mass being heavy, settles at the bottom, and in two or three days the muddy water is drawn off. The amalgam, or *pella*, which has been formed, is now taken from the *lavaderos* to a sort of oven or depression in the ground, covered with a huge metallic hood termed a *capellina*. A fire is built around the *capellina*, and the mercury is separated by distillation in about four days. The block of silver which remains is transported to the nearest mint, and worked into coin or sold.

The volcanoes form one of the most interesting features of the country. Only four of them are active, but no eruption has taken place from either of these during the present century. Earthquakes are, however, common, and *solfataras*, *fumaroles*, and adjoining warm springs, indicate that these volcanoes are still in a semi-active state. According to Humboldt, they lie on the same great vent of the earth's crust, and approximately on the nineteenth parallel of latitude. Orizaba, which may be reached from Esperanza on the railway from Vera Cruz to Mexico, has been quiet since 1566, but was reported to be smoking in April, 1883. There is no hazardous climbing on the mount-

FIG. 3.—POPOCATEPETL.

ain, but the ascent is exceedingly laborious on account of the steepness of the snow-clad cone. About five hours are required to reach the summit, but very few persons have thus far accomplished the task. The excursion to Popocatepetl starts from Amecameca, on the Morelos Railway, the road leading at first through fine wheat-fields watered by the melting snows of the great volcano. The path soon rises and

enters a magnificent forest, which is succeeded by a growth of thick grass, after which the crest-line of the ridge is crossed, and the ranch of Tlamacas, the starting-point for the summit, is reached. The lower part of the peak of the volcano has a slope of about 20°, and the angle increases in ascending till it reaches about 45° just below the summit. The crater is not visible until the traveler arrives at the edge. It is roughly estimated to be about five hundred yards in diameter and one hundred and fifty yards deep, and contains several *fumaroles*, with a small pond at its bottom. The temperature of the air on the summit at about ten o'clock in the morning was 32°. The view from the peak commands an area of about one hundred thousand square miles, and reaches to the Gulf of Mexico, one hundred and fifty miles distant. The descent may be made, if the snow is soft enough, by coasting on a sled. The volcano of Jorullo, in Michoacan, is famous for having been the result of a sudden eruption from a previously peaceful plain, on the night of the 28th—29th of September, 1759, the phenomena of which are fully related in a graphic description in Humboldt's "Cosmos." It is reached by a fifty-five-mile horseback-ride from Patzcuaro-station on the railroad from Mexico to Manzanillo. Horses may be ridden to within half a mile of the crater. The volcano is pear-shaped, with the outlet of the crater on the north side. The cone is covered with loose black ashes, in which a few bushes grow, and slopes at about 45° on the north and west sides. The crater is about a mile in circumference. The traveler may descend in it to the bottom, about five hundred feet below the summit. The walls slant rapidly, and are covered with an enormous mass of talus. Grass, a few ferns, and some native trees grow on its borders, and deer are abundant on the mountain. Shocks of earthquakes are often felt in the environs of Jorullo, one of which, in March, 1883, left cracks in the ground at a point ten miles off. Although no eruption has taken place for more than a hundred years, the volcano is still in a semi-active state, as is shown by the heat of the crater-walls, the emission of aqueous gas and vapor, and the frequency of earthquakes. A very extensive view is commanded from the summit.

Great interest is given to Mexico by its ancient ruins, relics of unknown people, whose character, origin, and history are destined long to be fruitful themes of study. They consist of *teocallis*, or pyramids, in different parts of the country, and the remains of elaborate buildings and of cities, chiefly situated in the States of Yucatan, Chiapas, and Oaxaca. The most prominently known ruins of cities are those of Uxmal, in Northern Yucatan, which are considered to be the oldest; those of Palenque, in Chiapas, next in age; and those of Mitla, in Oaxaca, third in age. The buildings were usually constructed of hewed stone, and have excited general admiration on account of the skill in architecture and the elaborate workmanship displayed in them. Near some of them are the remains of finely constructed artificial

lakes, with bottoms of cemented stones; and the traces of a very ancient paved road have been found in Yucatan. Charnay found the country in Yucatan covered with ruins from north to south; and Stephens, about 1840, visited forty-four ruined cities or places, in which remains of buildings were still found, most of which were unknown to white men, even to those inhabiting the country. The remains of Mayapan, the ancient capital of the Mayas, are scattered over a broad plain, and are characterized by a mound sixty feet high with a base a hundred feet square, the summit of which, a stone platform fifteen feet square, was reached by four stairways twenty-five feet wide. Another building is of stone, and circular, and stands on a sloping foundation thirty-five feet high. Near it are two rows of capitals, without columns.

The ruins of Uxmal are pronounced by Stephens, who explored them thoroughly, worthy to stand side by side with those of Egyptian and Roman art. The most important building, the Casa del Gobernador, is three hundred and twenty feet long, and was built of hewed stone laid in mortar or cement, and bore a cornice which was decorated all around with "one solid mass of rich, complicated, and elaborately sculptured ornaments." It stands on a foundation of three terraces, altogether forty-two feet high, the lowest of which was five hundred and seventy-five feet long. The remains of Chichen-Itza are similar to those of Uxmal. In one building the walls of the rooms are covered with picture-writing; and figures of serpents are a frequent ornament. At Ake, thirty-six columns, in three parallel rows, are all that remain of a once magnificent structure.

At Palenque, Captain del Rio found, in 1787, ruins extending seven or eight leagues one way and half a league the other, and visited and described fourteen edifices admirably built of hewed stone. The largest known building is two hundred and twenty-eight feet long, one hundred and eighty wide, and twenty-five feet high, built entirely of hewed stone, laid with admirable precision in excellent mortar, and it stood on a much larger terrraced pyramidal foundation. A corridor nine feet high, and roofed by a pointed arch, went round the building on the outside; and this was separated from another within of equal width. Other buildings are nearly as remarkable. Tablets, with elegantly carved inscriptions, are plentiful; and of the sculptured human figures Stephens says that "in justness of proportion and symmetry they must have approached the Greek models."

The four palaces, as Dupaix calls them, at Mitla, are said by him to have been "erected with lavish magnificence. . . . They combine the solidity of the works of Egypt with the elegance of those of Greece. But what is most remarkable, interesting, and striking in these monuments," he adds, "and which alone would be sufficient to give them the first rank among all known orders of architecture, is the execution of their mosaic *rilievos*, very different from plain mosaic,

and consequently requiring more ingenious combination and greater art and labor. They are inlaid on the surface of the wall, and their duration is owing to the method of fixing the prepared stones into the stone surface, which makes their union with it perfect." M. Charnay says that the beauty of these buildings can be matched only by that of the monuments of Greece and Rome in their best days.

The Pyramid of Cholula was one of the great edifices of the world. It was 1,423 feet wide at the base, 177 feet high, and covered a superficial area of forty-five acres. Civilized man is gradually destroying it, and a cut has been made in one side of it for a railroad-track. Near it are other smaller pyramids.

FIG. 4.—AZTEC TEMPLE AT CHOLULA.

The *teocallis* of San Juan Teotihuacan are next in age to those of Cholula. The two largest are dedicated to the Sun and the Moon. The former is 180 feet high, and 682 feet long at the base. Its summit—now marked by a platform about 75 feet square and a modern cylindrical monument of stone—is said to have been crowned with a temple, in which was a gigantic statue of the Sun, made of an entire block of stone, and wearing a breastplate of gold and silver. The two principal pyramids are surrounded by several smaller ones, few of which exceed twenty-five feet in height. According to tradition, they were dedicated to the Stars, and served as sepulchres for the illustrious men of the nation.

Toltec ruins are found at Tula, about fifty miles north of the capital.

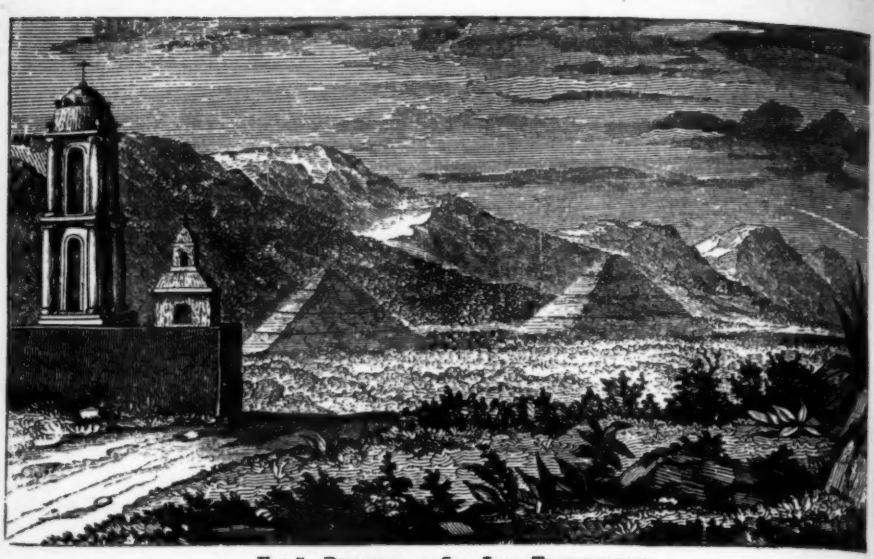

FIG. 5.—PYRAMIDS OF SAN JUAN TEOTIHUACAN.

At Papantla, in the State of Vera Cruz, is a pyramid remarkable for its symmetry, built of immense stones of porphyry, regularly cut and finely polished, many of which are covered with hieroglyphics, with carvings of serpents and crocodiles.

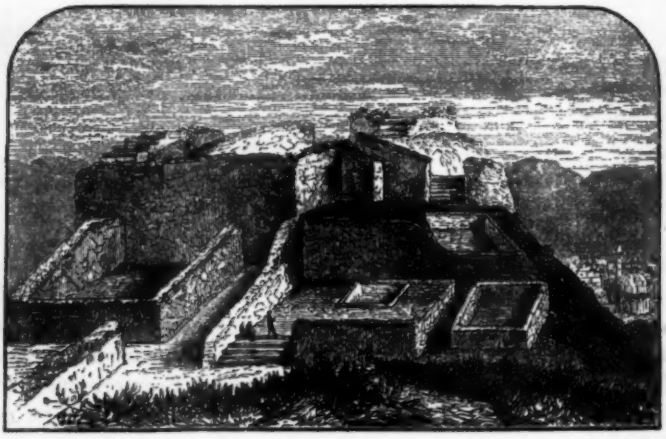

FIG. 6.—TOLTEC PALACE AT TULA.

The Museum of the city of Mexico contains a sacrificial stone, and a number of the idols of Aztec worship. We give cuts of two of these idols—Quetzalcoatl, the chief god of the people, and a feathered serpent.

The Marquis de Nadaillac, who has lately reviewed the whole sub-

ject of "Prehistoric Art in America," has given a graphical description of the Mexican ruins as a whole. "The massive constructions in Mexico and Peru," he says, "the immense spread of the bases and the inclination of the walls, give a pyramidal tendency and an appearance of stability and durability that force us to think of Egypt. Palenque, with its palaces, and Tiaguanuco, or Huanucho-Viejo, in Peru, with their monumental portals and their not numerous openings in the form of the *tau*, for the admittance of light, their walls covered with bright-red paint, and their figures always in profile, would not be out of place on the banks of the Nile. The bas-reliefs of Chichen-Itza resemble those of Babylon and Nineveh in richness of ornamentation. The meanderings of the friezes of Mitla, of the Casa del Gobernador, and the Casa de Monjas, at Uxmal, are of a kind with those of Greek art. The porch of Kabah, an aqueduct on the Rodadero, at Cuzco, might have stood on the Roman Campagna. The figures with which the temple of Xochicalco (Mexico) was adorned were represented sitting with crossed legs in the traditional attitude

FIG. 7.—QUETZALCOATL.

FIG. 8.—FEATHERED SERPENT.

of Buddha; and recently a Protestant missionary remarked upon the resemblances between the edifices at Chichen-Itza and the *topes* or *dagobas* he had seen at Anaradjapora, the ancient capital of Ceylon. The pyramids are certainly the most salient feature in this ancient architecture. The walls that still stand are composed of

immense blocks of granite or porphyry of cyclopean construction, or of mason-work of stone or brick covered with cement. All travelers have remarked the solidity and elegance of the building. The façades were regularly shaped, the joints well pointed, and the edges clean-cut. Generally, they were adorned with a projecting cornice loaded with rich ornaments in stucco. The possibly excessive monotony of the architecture was relieved by square towers several stories high. Such towers may be seen at Copan, Palenque, and Tikal; the Casa de la Culebra at Uxmal was crowned with thirteen turrets. The architects were also careful in placing statues, pilasters, caryatides, and bas-reliefs on the façades; and important mural paintings have been described at Chichen-Itza. They represent processions of men and animals, combats, struggles between man and the tiger or the serpent, trees, and houses. One painting, the only one relating to navigation, represents a boat somewhat like a Chinese junk.

"The sculptures that adorned these buildings," the marquis continues, "present so many differences in style and execution that we can hardly believe them the work of the same race, or that they represent the same civilization. In some cases they depict strange idols in incorrect forms, men wearing tigers' heads, an alligator holding in his jaws a figure with a human head and an animal's extremities, or a gigantic frog with his paws terminating in a cat's claws. Besides such monsters, we recollect at Copan a statue wearing the highest expression of Maya art, in which we know not whether to be most astonished at the oddity of the conception, the richness of the ornamentation, or the fineness of the execution. At Palenque we may see a statue with a placid expression that would not be out of place in the palace of a Pharaoh; and the sepulchral stone of Chac-Mol, recently found at Chichen, the bas-reliefs of Santa Lucia, and other works, are not discordant with modern art. These striking contrasts, while they bring no explanation, add, in the endless problems they raise, a new attraction to American archæology."

THE REMEDIES OF NATURE.

By FELIX L. OSWALD, M. D.

CATARRH.—PLEURISY.—CROUP.

THE progress of the *healing art*, as distinguished from certain sterile branches of medical science, can be best measured by the progress of our insight into the causes of special maladies. For the accidental discovery of a "specific" means generally nothing but the discovery of a method for suppressing special symptoms of a disease. Quinine subdues chills, but does not prevent a relapse of febrile affec-

tions; brandy neither cures nor subdues dyspepsia, but merely interrupts it with a transient alcohol-fever. But, as soon as we ascertained that scrofula, or the "king's-evil," was not caused by a mysterious dispensation of Providence, but by bad food and foul air, the cure of the disease became easy enough; the king's-evil disappeared without the aid of the king.

That "colds," or catarrhal affections, are so very common—so much, indeed, as to be considerably more frequent than all other diseases taken together—is mainly due to the fact that the cause of no other disorder of the human organism is so generally misunderstood. Few persons have recognized the origin of yellow fever; about the primary cause of asthma we are yet all in the dark; but in regard to "colds" alone the prevailing misconception of the truth has reached the degree of mistaking the cause for a cure, and the most effective cure for the cause of the disease. If we inquire after that cause, ninety-nine patients out of a hundred, and at least nine out of ten physicians, would answer, "Cold weather," "Raw March winds," or "Cold draughts," in other words, out-door air of a low temperature. If we inquire after the best cure, the answer would be, "Warmth and protection against cold draughts"—i. e., warm, stagnant, in-door air. Now, I maintain that it can be proved, with as absolute certainty as any physiological fact admits of being proved, that warm, vitiated in-door air is the cause, and cold out-door air the best cure, of catarrhs. Many people "catch cold" every month in the year and often two or three times a month. Very few get off with less than three colds a year; so that an annual average of five catarrhs would probably be an underestimate. For the United States alone that would give us a yearly aggregate of two hundred and fifty-five million "colds." That such facilities for investigation have failed to correct the errors of our exegetical theory is surely a striking proof how exclusively our dealings with disease have been limited to the endeavor of suppressing the symptoms instead of ascertaining and removing the cause. For, as a test of our unbiased faculty of observation, the degree of that failure would lead to rather unpronounceable conclusions. What should we think of the scientific acumen of a traveler who, after a careful examination of the available evidence, should persist in maintaining that mosquitoes are engendered by frost and exterminated by sunshine? Yet, if his attention had been chiefly devoted to the comparative study of mosquito-ointments and mosquito-bars, he might, for the rest, have been misled by such circumstances as the fact that mosquitoes abound near the ice-bound shores of Hudson Bay, and are rarely seen on the sunny prairies of Southern Texas. In all the civilized countries of the colder latitudes, catarrhs are frequent in winter and early spring, and less frequent in midsummer: hence the inference that catarrhs are caused by cold weather, and can be cured by warm air. Yet of the two fallacies the mosquito theory would, on the

whole, be the less preposterous mistake; for it is true that long droughts, by parching out the swamps, may sometimes reduce the mosquito-plague, but no kind of warm weather will mitigate a catarrh, while the patient persists in doing what thousands never cease to do the year round, namely, to expose their lungs, night after night, to the vitiated, sickening atmosphere of an unventilated bedroom. "Colds" are, indeed, less frequent in midwinter than at the beginning of spring. Frost is such a powerful disinfectant that in very cold nights the lung-poisoning atmosphere of few houses can resist its purifying influence; in spite of padded doors, in spite of "weather-strips" and double windows, it reduces the in-door temperature enough to paralyze the floating disease-germs. The penetrative force of a polar night-frost exercises that function with such resistless vigor that it defies the preventive measures of human skill; and all Arctic travelers agree that among the natives of Iceland, Greenland, and Labrador pulmonary diseases are actually unknown. Protracted cold weather thus prevents epidemic catarrhs, but during the first thaw * Nature succumbs to art: smoldering stove-fires add their fumes to the effluvia of the dormitory, tight-fitting doors and windows exclude the means of salvation: superstition triumphs; the lung-poison operates, and the next morning a snuffling, coughing, and red-nosed family discuss the cause of their affliction. "Taken cold"—that much they premise without debate. But where and when? Last evening, probably, when the warm south wind tempted them to open the window for a moment. Or "when those visitors kept chatting on the porch, and a drop of water from the thawing roof fell on my neck." Or else the boys caught it by playing in the garden and not changing their stockings when they came home. Resolved, that a person can not be too careful, as long as there is any snow on the ground. But even that explanation fails in spring; and, when the incubatory influence of the first moist heat is brought to bear on the lethargized catarrh-germs of a large city, a whole district-school is often turned into a snuffling-congress. The latter part of March is the season of epidemic colds.

The summer season, however, brings relief. In the sweltering summer nights of our large sea-board towns the outcry of instinct generally prevails against all arguments of superstition; parents know

* The correlation of damp weather and catarrhs can be explained by the fact that moisture lessens the modicum of fresh air which would otherwise penetrate a building in spite of closed windows. "All materials," says a correspondent of the "Revue des Deux Mondes," "become impermeable to the air when they are wet. It has been found less easy to drive moisture through bricks and mortar than to make air pass through them; only a few drops of the liquid can be made to appear on the opposite surface. Water is therefore not easy to dislodge from the pores it has occupied, and is removed at most very slowly by evaporation. But, when water stops the pores, it prevents the air from circulating through them—a mischievous effect upon the permeability of building materials."—(*Vide* "Popular Science Monthly" for December, 1883, p. 170.)

that their boys would desert and sleep in a ditch rather than endure the horrors of an air-tight sweat-box; so the windows are partially opened. The long, warm days also offer increased opportunities for out-door rambles. In midsummer, therefore, Nature rallies once more. But not always. There are people whose prejudices can not be shaken by experience, and in their households a perennial system of air-poisoning overcomes the redeeming tendencies of out-door life, as the subtile mixtures of La Brinvilliers overcame the iron constitution of her last husband. Their children snuffle the year round; no cough-medicine avails, no flannels and wrappers, even in the dog-days; and the evil is ascribed to "dampness," when the cold-air theory becomes at last too evidently preposterous.

To an unprejudiced observer, though, that theory is equally untenable in the coldest month of the year. No man can freeze himself into a catarrh. In cold weather the hospitals of our Northern cities sometimes receive patients with both feet and both hands frozen, with frost-bitten ears and frost-sore eyes, but without a trace of a catarrhal affection. Duck-hunters may wade all day in a frozen swamp without affecting the functions of their respiratory organs. Ice-cutters not rarely come in for an involuntary plunge-bath, and are obliged to let their clothes dry on their backs: it may result in a bowel-complaint, but no catarrh. Prolonged exposure to a cold storm may in rare cases induce a true pleural fever, a very troublesome affection, but as different from a "cold" as a headache is from a toothache—the upper air-passages remain unaffected. Sudden transition from heat to cold does not change the result. In winter the "pullers" of a rolling-mill have often to pass ten times an hour from the immediate neighborhood of a furnace to the chill draught of the open air; their skin becomes as rough as an armadillo's, their hair becomes grizzly or lead-colored; but no catarrh. On my last visit to Mexico, I ascended the peak of Orizaba from the south side, and reached the crater bathed in perspiration; and, following the guide across to the northwest slope, we were for ten minutes exposed to an ice-storm that swept the summit in blasts of fitful fury. Two of my companions, a boy of sixteen and an old army-surgeon, were not used to mountain-climbing, and could hardly walk when we got back to our camp in the foot-hills, but our lungs were none the worse for the adventure. Dr. Franklin, who, like Bacon and Goethe, had the gift of anticipative intuitions, seems to have suspected the mistake of the cold-air fallacy. "I shall not attempt to explain," says he, "why damp clothes occasion colds, rather than wet ones, because I doubt the fact; I believe that neither the one nor the other contributes to this effect, and that the causes of colds are totally independent of wet and even of cold" ("Miscellaneous Works," p. 216).

"I have, upon the approach of *colder* weather, removed my undergarments," says Dr. Page, "and have then attended to my out-door

affairs, minus the overcoat habitually worn; I have slept in winter in a current blowing directly about my head and shoulders; upon going to bed, I have sat in a strong current, *entirely nude*, for a quarter of an hour, on a very cold, damp night, in the fall of the year. These and similar experiments I have made repeatedly, and have never been able to catch cold. I became cold, sometimes quite cold, and became warm again, that is all" ("Natural Cure," p. 40).

There are many ways, less often sought than found, for "becoming quite cold, and warm again," but an experimenter, trying to contract a catarrh in that way, would soon give it up as a futile enterprise; after two or three attempts he would find the attainment of his purpose more hopeless than before; he would find that, instead of impairing, he had improved the functional vigor of his breathing-apparatus. Cold is a tonic that invigorates the respiratory organs when all other stimulants fail, and, combined with arm-exercise and certain dietetic alteratives, fresh, cold air is the best remedy for all the disorders of the lungs and upper air-passages. As soon as oppression of the chest, obstruction of the nasal ducts, and unusual lassitude indicate that a "cold has been taken"—in other words, that an air-poison has fastened upon the bronchi—its influence should at once be counteracted by the purest and coldest air available, and the patient should not stop to weigh the costs of a day's furlough against the danger of a chronic catarrh. In case imperative duties should interfere, the enemy must be met after dark, by devoting the first half of the night to an out-door campaign, and the second half to an encampment before a wide-open window. If the fight is to be short and decisive, the resources of the adversary must be diminished by a strict fast. Denutrition, or the temporary abstinence from food, is the most effective, and at the same time the safest, method for eliminating the morbid elements of the system; and there is little doubt that the proximate cause of a catarrh consists in the action of some microscopic parasite that develops its germs while the resistive power of the respiratory organs is diminished by the influence of impure air. Cold air arrests that development by direct paralysis. Toward the end of the year a damp, sultry day—the catarrh-weather *par excellence*—is sometimes followed by a sudden frost, and at such times I have often found that a six hours' inhalation of pure, cold night-air will free the obstructed air-passages so effectually that on the following morning hardly a slight huskiness of the voice suggests the narrowness of the escape from a two weeks' respiratory misery. But, aided by exercise, out-door air of any temperature will accomplish the same effect. In two days a resolute pedestrian can *walk away* from a summer catarrh of that malignant type that is apt to defy half-open windows. But the specific of the movement-cure is *arm-exercise*—dumb-bell swinging, grapple-swing practice, and wood-chopping. On a cold morning (for, after all, there are ten winter catarrhs to one in summer), a wood-shed *matinée*

seems to reach the seat of the disease by an air-line. As the chest begins to heave under the stimulus of the exercise, respiration becomes freer as it becomes deeper and fuller, expectoration ceases to be painful, and the mucus is at last discharged *en masse*, as if the system had only waited for that amount of encouragement to rid itself of the incubus. A catarrh can thus be broken up in a single day. For the next half-week the diet should be frugal and cooling. Fruit, light bread, and a little cold, sweet milk, is the best catarrh-diet. A fast-day, though, is still better. Fasting effects in a perfectly safe way what the old-school practitioners tried to accomplish by bleeding; it reduces the semi-febrile condition which accompanies every severe cold. There is no doubt that by exercise alone a catarrh can gradually be "worked off." But in-doors it is apt to be steep up-hill work, while cold air—even before the season of actual frosts—acts upon pulmonary disorders as it does upon malarial fevers: it reduces them to a less malignant type.

A combination of the three specifics—exercise, abstinence, and fresh air—will cure the most obstinate cold; only, the first signs of improvement should not encourage the convalescent to brave the atmosphere of a lung-poison den. So-called chronic catarrhs are, properly speaking, a succession of bronchial fevers. The popular idea that an average "cold" lasts about nine days, has some foundation in truth. Like other fevers, catarrhs have a self-limited period of development, but the recovery from the first attack constitutes no guarantee against an immediate relapse; on the contrary, the first seizure appears to prepare the way for its successors. A long sojourn in an absolutely pure atmosphere, as in a summer camp on the mountains, seems for a while to make the lungs catarrh-proof, by increasing the vigor of their resisting ability, and the returned tourist may find to his surprise that the air of his family den can now be breathed without the wonted consequences. But the addition of a stove or a double window at last turns the scales against Nature, and the first malignant cold reproduces the sensitiveness of the respiratory organs.

After recovery from a chronic catarrh the danger of contagion should therefore be carefully avoided. In many of our Northern cities ill-ventilated reading-rooms are veritable hot-beds of lung-poison, as crowded court-rooms in the villages, and taverns and quilting-assemblies in the backwoods. Meeting-houses, with their large windows and small, rarely-used stoves, are less dangerous; but stuffy school-rooms are as prolific of colds as swamps of mosquitoes, and often counteract all sanitary precautions of the domestic arrangements. Stuffed railway-cars, too, could claim a premium as galloping-consumption factories; and after dark the retreat to an over-heated "Pullman sleeper" would hardly increase the chances of longevity; the best plan for long-distance travelers would, on the whole, be to secure a rear seat, where open windows are less apt to awaken the

groans of air-fearing fellow-passengers, and risk cinders and smoke rather than the miasma of the galloping man-pen.

It would be a mistake to suppose that "colds" can be propagated only by direct transmission or the breathing of recently vitiated air. Catarrh-germs, floating in the atmosphere of an ill-ventilated bedroom, may preserve their vitality for weeks after the house has been abandoned; and the next renter of such a place should not move in till wide-open windows and doors and a thorough draught of several days has removed every trace of a "musty" smell.

If a bronchial catarrh is accompanied by a persistent *cough*, it indicates that the affection is deep-seated, and that it has probably spread to the upper lobes of the lungs. Arm-exercise and a mild, saccharine diet generally suffice to loosen the phlegm and thereby remove the proximate cause of the evil. But, if those remedies fail, there is a presumption that the chronic character of the affection is due to a permanent external cause of irritation, which can be removed only by a change of air. In such cases cough-sirups merely palliate the evil. Medicines, counter-irritants, and fasting are in vain, if the lungs of the patient are constantly impregnated with new morbific germs; even exercise can do little more than alleviate the distress of the symptoms; a radical cure is impossible as long as every night undoes the work of the preceding day. In a home of prejudices the patient should at once change his bedroom and take care to profit by the change.

A neglected catarrh may result in an attack of *pleurisy*. Each lung is inclosed in a sack-like serous membrane, which connects with a similar membrane lining the inner surface of the chest. This double integument, known as the *pleura*, or the visceral and parietal layer of the pleural membrane, communicates both with the lungs and with the upper air-passages, and is more or less affected by every morbid condition of the respiratory organs. *Pleurisy*, or the congestion of the pleural membrane, is generally an inflammatory complication of a chronic catarrh. The original affection may have apparently subsided. Counter-irritants, alcoholic tonics, etc., have subdued the cough; with the exception of an occasional uneasiness about the chest, the condition of the patient seems greatly improved; only an abnormally rapid pulse justifies a suspicion that the smothered fire has not been wholly extinguished. A change of residence or plenty of out-door exercise may perhaps ratify the sham-cure. A normal pulse would give assurance that the masked fever has really subsided. But under less favorable circumstances an oppressive heat and a strange feeling of uneasiness will some day announce the approaching crisis of the latent disorder. Chills follow at shorter and shorter intervals, and at last a pricking pang in the region of the upper ribs reveals the seat of the affection. Breathing soon becomes so painful that the patient finds no rest in a horizontal position, but has to sit up in his bed, and may

feel sorely tempted to relieve his distress by invoking the aid of the drug-gods. For believers in the remedial resources of Nature, pleurisy is, indeed, a crucial test of faith, and Dr. Isaac Jennings's observations on his experience during an acute attack of the disease deserve to be framed in every hygienic sanitarium.

"For twelve hours," says he, "breathing was at best laborious and painful, confining me to nearly an erect position in bed; but the distress occasioned by efforts at coughing was indescribable. The confidence of my wife in the 'let-alone' treatment, which had been strengthening for years, and had carried her unflinchingly through a number of serious indispositions, on this occasion faltered; and she begged me to let her send for a physician to bleed me or do something to give at least temporary relief; 'for,' said she, 'you *can not* live so.' In my own mind there was not the least vestige of misgiving respecting the course pursued.

"In view of the constitutional defect in the pulmonary department of my system, and the nature and severity of the symptoms, it appeared to me very doubtful whether the powers of life would hold out and be able to accomplish what they had undertaken and put me again upon my feet. But I felt perfectly satisfied that whatever could be done to good purpose would be done, by 'due course of law.' My mind, therefore, was perfectly at ease in trusting Nature's work in Nature's hands. There was no danger in the symptoms, let them run as high as they would. They constituted no part of the real difficulty, but grew out of it. The general movement which made them necessary was aiming directly at the removal of that difficulty. Instead, therefore, of being troubled with the idea that I could not live with such symptoms, my conviction was very strong that I could live better with them than without them.

"In the morning, ten or twelve hours from the beginning of the cold chill, there was some mitigation of suffering, which continued till afternoon, when there was a slight exacerbation of symptoms; but the heaviest part of the work was accomplished within the first twenty-four hours. From that time there was a gradual declension of painful symptoms, till the fifth day, when debility and expectoration constituted the bulk of the disease.

"Full bleeding at the commencement of the disease, followed by the other 'break-up' means usually employed in such affections, would have given me immediate relief, and, by continuing to ply active means as the work was urged on (for there would have been no stopping of it, short of stopping the action of the heart), the strongest, most distressing, and critical part of the disease might have been pushed forward to the fifth day; and I might even then possibly have recovered. But, granting that my life would have been spared, I suffered much less on the whole under the 'let alone' treatment than I should have done under a perturbating one, besides having the curative process con-

ducted with more regularity, made shorter, and done up more effectually" ("Medical Reform," p. 312).

After the paroxysm of the disease has subsided, the pectoral fever can be alleviated by the free use of cold water and strict abstinence from solid food. Avoid over-warm bedclothing. By a load of warm covers alone a common catarrh can be aggravated into a hot fever till the blanket-smothered patient is awakened by the throbbing of a galloping pulse. Exercise would promote the discharge of the accumulated serum, but, while the patient is too sore to turn over in his bed, gymnastics are out of the question, and their effect must be accomplished by "passive exercise," manipulation of the thorax, and a swinging motion in a hammock or a rocking easy-chair. With the aid of fresh air and abstinence the remedies of the movement-cure might be entirely dispensed with, if the accumulation of purulent matter were the only risk, but in acute pleurisy there is a greater danger from another cause, namely, that the inflamed surface of the visceral pleura has a tendency to adhere to the lining of the thorax and thus obliterate the pleural cavity. The consequences of that result would be a permanent embarrassment of breathing, or even the total paralysis of the affected lung. Passive exercise and friction (rubbing the less affected parts of the chest with a bathing-brush) will, however, not fail to obviate that danger. As soon as Nature finds relief in a copious expectoration, the crisis of the disease is weathered, and further precautions may be limited to rest and a sparse but emulsive diet—a modicum of sweet cream, with oatmeal-gruel and stewed raisins. That pleurisy was formerly considered a most fatal disease can be more than sufficiently explained by the fatal measures of treatment which were then in vogue. Dr. Buchan's "Family Medical Library," not more than thirty years ago about the most popular pathological compend, contains the following directions: "In the beginning of a pleurisy the only efficient course is to make the patient stand up on the floor, while blood is drawn from a large orifice *until he faints or is about falling*. . . . If, after the first bleeding, the pain, with the other violent symptoms, should still continue, it will be necessary to take eight or nine ounces more. If the symptoms do not then abate, and the blood shows a strong buffy-coat, *a third or even a fourth bleeding may be requisite*. . . . Topical bleeding has also a good effect in this disease. It may be performed by applying a number of leeches to the parts affected, or by cupping, which is both a more certain and expeditious method than the other. . . . Then, take: Solution of acetated ammonia, three drachms; mint-water, one ounce; tincture of opium, twenty-five drops; sirup of tolu, two drachms; antimonial wine, thirty drops. Nothing is so certain to give speedy and permanent relief as a combination of ipecac, calomel, and opium." And in that form of the disease known as "bilious pleurisy," "emetics and mercurial cathartics are of the utmost im-

portance. . . . Purgatives should be continued through the whole course of the disease; . . . a blister should be applied *of sufficient size to embrace the whole breast"!* ("Family Medical Library," pages 174, 183).

Croup is an obstruction of the upper air-tubes, induced by the lethargic influence of overfeeding and warm, impure air. How an overloaded stomach reacts on the functions of the respiratory organs, many adults have an opportunity to experience in the strangling sensations of a "nightmare," though the respiratory stimulus of the cool night-air generally helps to overcome such affections, especially if the sufferer can ease his lungs by a contraction of his arms or by turning over on his side. But infants are not only more grossly overfed than the most gluttonous adults, while the phlegm-producing quality of their food increases the danger of respiratory obstructions, but that danger is still aggravated by feeding their lungs on the sickening air of an overheated and ill-ventilated bedroom, and still further aggravated by swaddling and bandaging them in a way to prevent every motion that might help to ease their distress. *Spasmodic croup* generally occurs after the establishment of a plethoric diathesis—after persistent overfeeding has turned a baby into a mass of fat and fretful sickliness. Some night, usually after a heavy surfeit, the child is awakened by a feeling of suffocation and gasps for breath till the obstruction is removed by a violent fit of coughing. "Croup-sirup" (treacle and laudanum) subdues the symptoms by lethargizing the irritability—for a little while, for soon a second and more violent fit has to complete the work of the first paroxysm by expelling the accumulated phlegm.

But a far more dangerous form of the disease is developed when the predisposing causes are aggravated by an inflammation of the larynx. Inflammatory croup, or exudative laryngitis,* does not occur unawares, but is preceded by a very peculiar cough, a hoarse, cough-like bark, mingled with strange wheezing and metallic sounds. The windpipe is congested, and in that note of warning appeals for relief from impure air and deliverance from the influence of a crapulent diet. Nine times out of ten the effect of its appeal is a dose of narcotic cough-medicine, more tightly-closed windows and a hotter stove. The process of surfeit in the mean while continues; the windpipe, already abnormally contracted by its inflamed condition, becomes less and less able to resist the obstructing influence of the accumulated phlegm; at night, when the exclusion of every breath of fresh air † has

* Called also "true croup," or "pseudo-membranous laryngitis," "plastic laryngitis."

† "I lately attended an infant, whom I found muffled up over head and ears in many folds of flannel, though it was in the middle of June. I begged for a little free air to the poor creature; but, though this indulgence was granted during my stay, I found it always on my return in the same situation. Death, as might have been expected, soon freed the infant from all its miseries; but it was not in my power to free the minds of its parents from those prejudices which proved fatal to their child" (Dr. G. G. Norwood, "Management of Children," p. 619).

still further reduced the functional energy of the respiratory organs, a viscid matter rises in bubbles, and one of these bubbles, like a tenacious membrane, closes the tube of the larynx. Suffocation results, and, in the ensuing struggle for life, Nature has a very slim chance to prevail. In our Northern States alone, five or six thousand perish thus every year—killed by domestic contrivances as surely as the prisoners of Surajah Dowlah were killed by the architectural arrangements of the Black Hole. If the physician is only called in the last stage of the *deliquium*, inflammatory croup constitutes one of those exceptional cases where artificial causes of disease have to be met by artificial remedies. The far-gone exhaustion of the patient, a thin, expiring pulse, would indicate that tracheotomy, or the opening of the windpipe, offers the only hope of salvation. A violent, suffocating, and spasmodic cough would indicate that the expulsive efforts of Nature require the aid of a swift emetic—tartar or ipecacuanha.

But, if the symptoms of danger are heeded in time, croup is as curable as a common catarrh. As soon as the characteristic cough betrays the condition of the windpipe, the patient—infant or adult—should be reduced to two meals, the last one not later than four hours before sunset. Flesh-food, greasy made-dishes, narcotic drinks, as well as all kinds of alcoholic stimulants, should be strictly avoided. Before night *the bed should be removed to a cool and carefully ventilated room.* Families who have no alternative should not hesitate to open every window for at least fifteen minutes, and in the mean while compromise with their prejudices by carrying the child to the next neighbors, rather than bring it back before the air of the bedroom has been thoroughly purified. A draught of very cold air might possibly excite a cough that would precipitate the crisis of the disease, though by no means lessen the chances of a lucky issue. But more probably fresh air, whether cold or cool, would so re-enforce the remedial resources of Nature that the inflammation would subside in the course of a few days.

If in spite of such precautions a strangling-fit should occur at night, the child should be immediately *raised to a half-upright position*, by making the weight of the body rest on the knees, with the head slightly inclined (face downward), the elbows back, and the hands resting against the hips—the position which a person would instinctively assume in the endeavor to aid an expulsive effort of the lungs. Between the paroxysms ease the chest by a *quick forward-and-backward movement of the arms*, and by *persistent friction with a wet brush, applied to the neck and the upper ribs.* Under the influence of these stimulants, combined with the invigorating tendency of fresh air, the organism will employ all its resources to the best advantage and soon relieve itself by a sort of retching cough. If the difficulty has not been aggravated by the use of "croup-sirup," the patient will rest at ease for the remaining hours of the night. A week may go by with-

out a recurrence of the suffocating fit ; but only the subsidence of the inflammation — indicated by the diminished hoarseness of the cough—gives a guarantee that the danger is past.

STUDY—PHYSIOLOGICALLY CONSIDERED.

By P. J. HIGGINS, M. D.

THE ultimate element by means of which those processes that constitute the mind are carried on, is the microscopic cell of the gray matter of the brain. These gray nerve-cells, with the delicate tissue in which they are imbedded, form a layer, from one sixth to one twelfth of an inch in thickness, on the surface of the brain. This area would be small, were it not disposed in folds or convolutions which greatly increase its extent. It is upon the number and quality of these nerve-cells, and the systematic exercise of their function, rather than upon mere size or weight of brain, that the mental capacity of the individual depends.

The activity of the nerve-cells of the brain, in other words, depends partly upon their inherent vitality or vigor of constitution, and partly upon the quantity and quality of their blood-supply. They may be stimulated into unwonted activity by an effort of the will or the spur of excited consciousness ; but even in these cases, should the strain last any length of time, the blood-supply is quickly and largely increased.

Skeptics may cavil, but the solid fact remains that strength of intellect, like that of muscle, is frequently inherited. Capacities differ from the beginning. For this reason, children can not be expected to make equal progress under any system of teaching, any more than horses upon a race-course. But, by persistent and judicious training, the strength, speed, and endurance of all may be increased through a steady and gradual development.

In order that the teacher may utilize his efforts to the best advantage, he should understand the laws of the mind's development, and the influences that modify and regulate its activity. Mental philosophy deals with the former—to explain some of the latter is the object of this paper.

The brain-substance may be touched, and even cut, with little or no consciousness of sensation; yet the gray nerve-matter is very delicate in construction, and exquisitely sensitive to changes in its blood-supply. Like other organs, it is exhausted by continued activity, and needs rest in order to recuperate its vitality. All tissues wear more or less by work ; that is, molecules of their cell-substance die and become foreign matter, which must be cast off and replaced by new material.

This new material is absorbed by the cells from the blood, through the thin walls of the minute blood-vessels in their vicinity. Through the walls of the same vessels the cast-off matters pass in the opposite direction into the circulation and are washed away by its current. While the tissue is hard at work, the process of disintegration is at a maximum, and that of repair at the opposite extreme—consequently the waste is produced more rapidly than it can be carried away, and accumulates. As ashes in a stove interfere with combustion, it impedes the current of thought, and lessens its intensity. But, during repose, the opposite conditions obtain—repair is at its maximum, and waste almost or entirely suspended. The blood has been busy all night ridding itself and the tissues of all impurities, and is richly charged with oxygen. The brain, and consequently the mind, is fresh and vigorous after the night's repose; the damages have been all repaired, and the *débris* cleared away. It is a matter even of common observation that at no other time is the mind so sharp, clear, and strong, as in the morning.

Concrete ideas tax the mind but lightly. The more abstract ideas become, the more difficult is their comprehension, and the greater the nervous strain involved in their contemplation. For this reason, the abstruse studies should be taken up during the forenoon session, as the faculties of the mind are then in the most favorable condition to grapple with their difficulties.

Of all school-studies, mathematics requires the strongest grasp of mind, and the closest exercise of the reasoning powers and the judgment. In abstruseness and difficulty of comprehension, geometry, algebra, and arithmetic, rank in the order enumerated. Rhetoric, including grammar and composition, comes next. In every school and college, therefore, these subjects should be taken up during the morning session.

The mind learns by means of impressions made upon the gray nerve-cells, through the senses, of which sight is the most vivid and durable in its effects. Hearing ranks next, but its impressions are less vivid and more fleeting. Further, they are recalled to the memory less readily and distinctly. We all remember what we see longer than what we hear. Hence the most reliance should be placed upon the eye as an avenue of instruction, and the teacher should make use of it whenever practicable. When an impression is made upon a nerve-cell, it is said to retain it "in potency"—that is, it is capable of renewing it by an exercise of the memory. Now, the clearness and permanence of a mental impression depend—(*a*) upon its vividness; (*b*) upon the frequency of its repetition; and (*c*) upon the inherent vigor of the nerve-cell.

To obtain vividness of impression, the teacher's language should be clear and simple; his descriptions of processes and objects sharp and vivid; he must present the same ideas again and again, in order to fix

them permanently in the memory. The inherent vigor of the mind can be strengthened by systematic exercise, just as the muscles of a blacksmith's arm become strong and brawny by years of daily toil at the clinking anvil.

Throughout animated nature, a period of repose succeeds one of activity, both recurring in regular alternation. The vegetable world grows and blooms; then, for a season, all the vital processes stand still. Work brings weariness, which rest must dissipate. So is it with the tissues of the body; and the younger and more delicately organized they are, the sooner does toil exhaust them. Brain-matter is the most delicate of all our tissues, and nearly one third of the pure blood thrown out by the heart at each contraction goes to supply it. A tissue, when at work, has its blood-supply largely increased. When the mind is actively engaged in study, the circulation in the brain is full and active, the temperature is raised, even the face is flushed; and the more difficult the study, the more these effects are intensified. After a time, the brain becomes so engorged with blood that its activity is depressed and its energies begin to flag. The younger a pupil is, the sooner does his mind grow tired. Between the ages of six and seven, the lessons should not exceed ten minutes' duration, as young children are unable to keep their attention fixed upon one subject for a greater length of time. It may be laid down as a safe rule, that close mental application for an hour and a half will tire out the majority of pupils, and leave them unfit and indisposed to proceed further without a relaxation of at least ten or fifteen minutes.

Here the forenoon recess is indicated—not, as some imagine, simply to kill time, but as a positive physical necessity, not for the pupil alone, but also for the teacher. The worry and mental strain of governing a roomful of nervous, restless children, and teaching at the same time, no one can fully realize without actual experience.

How should recess be spent by the pupil? To reply to this, his physical condition must be considered. As the blood is contained in a series of closed vessels, it is evident that, if the circulation be increased in one portion, it is correspondingly diminished in another. When the brain is engorged, some other portion of the economy must be under-supplied. By a wise provision of Nature, the surplus is drawn from the tissue that is least active—in this case, from the muscular system. The indication is to relieve the congested brain, and this is best met by muscular exercise, as a tissue in action has its blood-supply largely increased. The muscular system is of considerable extent, and the exercise that brings the most muscle into action is the most beneficial.

Therefore, during recess, nothing can take the place of active exercise in the open air.

But if the temperature is very low, recess had better be taken indoors, for the intense cold exhausts the vitality by drawing largely

upon the heat-supply. By constringing the cutaneous vessels, it congests the internal organs and weakens the heart, while it requires some time to restore the equilibrium of the circulation. In rainy weather, the result is still more detrimental. In a climate like ours, exposure to rain is at all times fraught with danger to health, and particularly when one sits still in wet or damp garments for any great length of time. No recess out-doors, on a bitterly cold or rainy day, should be the rule, and gymnastic exercises, calisthenics, motion-songs, etc., should take its place. Every grammar-school should have one room fitted up as a gymnasium. There is a certain amount of nerve-energy that is accustomed to find outlet in the muscles, and, if unduly repressed, it will often break through the strictest discipline and cause the teacher much annoyance. It must not be forgotten that muscles were not created to be kept still during waking hours, and, when kept at rest an hour or two, a surplus of energy accumulates, which recess gets rid of legitimately. It also serves another purpose admirably. Of all sedatives of the nervous system, muscular exercise is the most efficient, because physiological. It quickens the circulation, and stimulates the heart and all the vegetative functions.

After exercise, the muscles—of the hand and forearm particularly—are subject to rhythmic, automatic waves of contraction; that is, there is a tremor beyond the power of the will to control. So that writing and drawing, which require great steadiness of the hand and fingers, should never be taken up after recess, or at the commencement of the afternoon session. Of the elementary studies, mental arithmetic involves the closest application of the highest powers of the mind—drawing at once upon memory, reason, and judgment—and this may be taken up advantageously from half-past eleven to twelve. Breakfast digestion is then nearly if not quite completed, and intense application is least detrimental to the vegetative system.

The morning meal is usually light in material and amount; dinner, partaken of soon after noon (except in the largest cities), is the principal meal. It is "solid," in a physiological not less than in a popular sense, for it is most generous in amount, and usually rich in nitrogenized matters—flesh-meat, puddings, eggs, etc. After its ingestion, the digestive organs are taxed to their utmost capacity, and soon become loaded and distended with blood. The digestive system is quite extensive, and is richly supplied with blood-vessels, which are imbedded in rather loose tissue, so that they may dilate, to accommodate the sudden influx from the outlying portions of the body, together with the newly-absorbed products of digestion. The brain is thus deprived of its full supply; and if, by reason of severe study, it draws upon the circulation, the digestive organs are robbed of their needs, and their efficiency interfered with seriously. Intense application at this time does harm in another way. All the functions of the body are under nervous control. The digestive organs are mainly innervated by the

pneumogastrics—two nerves arising from the lower portion of the brain, near the base. Now, the thinking portion of the brain being situated on the convex surface, deep and perplexing thought robs the roots of the pneumogastric nerves of their circulation, and in this way depresses their influence. Lacking the proper nervous stimulus, the digestive juices become scanty in amount; peristalsis is enfeebled; the liver—that refinery where the crude products of digestion are purified and elaborated—loses tone, and allows the peptones to pass unchanged into the general circulation, giving rise to much discomfort and mental depression. Thus are laid the foundations of dyspepsia, that common complaint of students; and in the higher institutions of learning, where the course is difficult and protracted, many, after graduation, return home invalids—often only to die.

The products of digestion are taken up by two different sets of vessels. The fatty matters, in the form of an emulsion, go almost directly to the right side of the heart; while the others, before entering the general circulation, pass through the liver. A portion of the refuse is excreted here; the rest, remaining in solution in the blood, is carried to other organs to be gradually eliminated. So that, during digestion, the blood is not only charged with impurities from the alimentary canal, but also with newly or imperfectly formed material.

The brain, then, being deprived of its full blood-supply, and the blood itself being impure and impoverished, it may at once be seen that the mind is not very active after dinner, and by no means fitted for severe study. Hence the lighter subjects—reading, geography, history, writing, drawing, music—should occupy the afternoon session, as these subjects involve chiefly the imitative faculty and the memory. Of these, reading and music—the lightest of all—should precede; dictation and geography may follow. When the programme includes an afternoon recess, history may follow with advantage. The most appropriate time for writing and drawing is from half-past three to four. The muscles of the hand are steady, the pupils are fatigued mentally, and the imitative faculty—the lowest in the scale—is the only one called into play.

Two o'clock may be set down as the most judicious time for the opening of the afternoon session. Half-past one is not quite so good, but will answer very well. To begin at one is a positive detriment. The pupils hurry home, snatch a hasty dinner, and as hurriedly return. Those who dwell at some distance are often late. Some are obliged to attend to household duties, and this also occasions tardiness. Sunlight is cheap and plenty, and the half-hour gained would be more useful if taken at the end of the session. Indeed, two hours' steady work will exhaust the majority of children, and will leave all seriously disinclined to exertion. When school assembles at two, and is dismissed at four, no recess is necessary, if the plan here indicated is followed, for the work is much lighter than during the morning session.

Of late certain spasmodic efforts have been made to abolish recess, and hold but one long session per day—from nine to one or half-past one; but this is a mistaken notion, founded on lack of knowledge of the effects of long-continued study and the physical needs of the young. It is true that in some of the largest cities this plan is followed in the high-schools, but the cause is local, for the pupils come from long distances—in New York city, for instance, as far as five miles. Besides, in many of these schools the pupils do much of their studying at their homes, and the majority are in the neighborhood of twenty years of age, so that they are in a better condition to stand the additional strain without injury.

Anything that distracts the pupil's attention from his studies retards his progress, by making less vivid the impressions received by the nerve-cells; for, by concentrating the mental vision upon one point, to the exclusion of others, we see that point more distinctly. All peripheral irritation, therefore, should be removed as far as possible. The distraction of discomfort, particularly of the cutaneous surface, is a serious drawback; comfortable seats—preferably single—high enough to support the lower limbs, and desks of the proper height to rest the arms, are in this way valuable indirect aids to study. But of all peripheral irritation, that produced by cold is perhaps the most distracting. When the temperature of the room falls below 50° Fahr., the next exercise should be dismissal. Between 50° and 70° the temperature may range; but from 60° to 65° is the safest and most comfortable; safest, because the cutaneous surface does not become overheated and congested—liable to be chilled by the lower temperature of the open air—and most comfortable, because neither heat nor cold is perceptible. It is needless to add that every school-room should have a thermometer, which the teacher should frequently consult, and govern himself according to its indications.

For the reasons noted above, children at home should not be allowed to prepare their lessons immediately after supper, or late into the night; for study congests the brain, and, as sleep is produced by the opposite condition, they lie awake and restless until the amount and pressure of blood within the cranium are greatly diminished.

Strange as the assertion may seem, a pupil's diet has much to do with his progress. A liberal supply of non-stimulating food—in other words, bread, milk, vegetables, fruits, and a farinaceous diet principally—is far superior for the healthy growth of bone and nerve and muscle than a regimen into which nitrogenized materials—flesh-meat, eggs, etc.—enter largely. These latter unduly stimulate the nervous system, cause a premature development of the body, and load the blood with impurities, that tax the liver and the excretory organs sorely. In a warm climate, such as ours, the liver, choked with albuminoids, will fail in its function periodically, through sheer fatigue; the bilious matters then circulate throughout the system and stain the complex-

ion; torpor, *malaise*, and headache, will result. In this condition study is a task instead of a pleasure; the mind is weak, and the memory can not retain imparted knowledge for any great length of time.

In general terms, it may be laid down as a rule, that much effective study must not be expected from a pupil who is overfed, especially if on rich and stimulating food. Let it not be understood that flesh-meat should be excluded from the diet of the young. By no means; it is only its excess that is objected to. An overfed pupil is indolent, intellectually, not because he may be so inclined willfully, but for the reason that his digestive organs rob his brain, and his blood is charged with effete matter; in figurative phrase, the fire is slow because the stove is filled with coal and choked with ashes.

To recapitulate: The more abstruse studies—mathematics, science, rhetoric—should be taken up during the morning session. The proper time for the forenoon recess is at half-past ten. The lighter or concrete subjects—reading, history, geography, writing, drawing, music—should occupy the afternoon session, commencing preferably at two o'clock. When it begins at half-past one, a recess of ten or fifteen minutes is necessary, preferably the quarter-hour preceding three o'clock. No out-door recess when the weather is inclement. For the younger pupils, short lessons frequently repeated, exercising chiefly the imitative faculty and the memory, should be the rule.

FASHION AND DEFORMITY IN THE FEET.

By ADA H. KEPLEY.

"A WELL-FORMED foot," says Chapman in "The American Drawing-Book," "is rarely to be met with in our day, from the lamentable distortion it is doomed to endure by the fashion of our shoes and boots. Instead of being allowed the same freedom as the fingers to exercise the purposes for which Nature intended them, the toes are cramped together, and are of little more value than if they were all in one; their joints enlarged, stiffened, and distorted, forced and packed together, often overlapping one another in sad confusion, and wantonly placed beyond the power of service. As for the little-toe and its neighbor, in a shoe-deformed foot, they are usually thrust out of the way altogether, as if considered supernumerary and useless, while all the work is thrown upon the great-toe, although that too is scarcely allowed working-room in its prison-house of leather. It is, therefore, hopeless to look for a foot that has grown under the restraints of leather, for perfection of form; and hence the feet of children, although less marked in their external anatomical development, present the best models for the study and exercise of the pupil in drawing."

Camper, who wrote, in the seventeenth century, "On the Best Form of Shoe," says that his treatise originated in a jest made with his pupils, who "did not believe I should dare to make public a work on such a subject," which indicates the small estimate that was put upon the foot as an organ of the body. He begins by deploring the perversity which wholly neglects the human feet, while forcing the greatest attention to the feet of "horses, mules, oxen, and other animals of burden," and declares that from the earliest infancy the foot-coverings worn serve but to deform them, and make walking painful, and sometimes impossible; and he lays the blame on the ignorance of shoemakers.

James Dowie, a practical and scientific Scotch shoemaker, in his excellent little book, makes the same statements as the artist; and the great Dutch surgeon, whose treatise he had translated into the English language, also laments that the subject of the feet is so neglected by those who are competent to instruct us about them. Lord Palmerston said to Dowie that "shoemakers should all be treated like pirates, put to death without trial or mercy, as they had inflicted more suffering on mankind than any class he knew."

Fig. 1.

One can not treat of the deformities of the feet without considering the nature of their covering, the boots and shoes, for it is these which cramp, distort, and disable them; therefore in this article, after a brief account of the anatomy of the foot, our attention will be confined to its principal distortions and the causes which produce them.

The feet furnish a firm base for the body in standing, and, undeformed, make walking easy and healthful. They sustain alternately the whole of the body's weight, and, though comparatively small, are admirably fitted to carry it without jar or discomfort, if unhampered by their coverings. They are in the highest degree elastic, from the large number of bones, with many articulations, with their attachments, and the plentiful supply of muscles, blood-vessels, and nerves to keep them vigorous and well-nourished. This elasticity enables them to carry the body over smooth and rough surfaces, not only without injury, but to its greater health. In just so far as this elasticity and freedom of natural action are interfered with, is their health, and with it that of the body, lowered.

Anatomists divide the skeleton of the foot into three portions, the tarsus, with seven bones, forming the heel and arch bones; the metatarsus, with five bones just forward of the tarsus; and the toes, which contain fourteen bones, two in the great-toe, three in each of the other toes; beneath the ball of the foot, as it is called, are two small bones, which lie under the articulation of the great-toe and the adjoining metatarsal bones, making twenty-eight bones in each foot (see Figs. 16, 17, 19).

The large articulating surface of the feet, and their numerous blood-vessels, muscles, nerves, etc., render it peculiarly susceptible to injuries. Their distance from the center of circulation, together with the variations of temperature they have to endure, make them extremely liable to contract disease.

It seems as if the general injuries to the body resulting from diseased and crippled feet should be plain enough to attract attention, but such does not appear to be the case. No complete treatise on the feet has been produced. Physicians as a class seem to pay the subject but little attention. In the books in which the diseases and injuries of the feet are considered, the causes of disease, if stated, seem to be mentioned incidentally, and without proper notice of the connection between the diseases and the bad physiological conditions they induce. Physicians will prescribe for diseases caused largely by unsuitable clothing of the feet, without saying anything of the reform in the *chaussure* by means of which the disorder might be greatly mitigated, if not cured. A delicate woman was treated for months for a peculiar disease which made her a complete invalid, by an eminent specialist, who said nothing of the high-heeled, paper-soled, thin boots, the habitual wearing of which greatly aggravated her disorder. A paper showing the deleterious effects of such shoes on the health of women, read at a recent meeting of an association of doctors, seemed, according to the reports, to call out more objectors than it found friends. A competent woman physician excused herself for wearing such shoes because it was so hard to find hygienic shoes in stock, and added that, when physicians prescribed reforms in clothing, they had to be politic, to keep their patients; and when asked if she ever saw a woman who wore tight shoes, replied "No"; nor did she know any who wore tight corsets.

FIG. 2.

Walking is the exercise that, more than any other, brings every portion of the system into healthful activity. Many complaints would disappear under a thorough and careful course of pedestrianism; but who can walk if the feet are sore or diseased? General bad condi-

tions arise from lack of exercise, which invigorates the muscles and oxygenizes the vital fluid. Dyspepsia is the usual attendant on such conditions, and may manifest itself either by general emaciation or by fatty degeneration.

The feet demand a covering which shall conform to their shape, allow them free play, and afford protection from injuries.* Dowie scoffingly remarks, in his treatise, respecting shoes so cut at the toes as to represent the foot like that of a goose, with the great-toe in the middle. We are now in an era of "pencil-toed" shoes, so called, which recall Dowie's comparison. It is difficult to understand how shoemakers can be so careless of the shape of the feet and their needs as to cut shoes that in the toe are the very reverse of what toes demand; but it is more difficult to conceive how any one can endure the suffering they inflict. Dowie insists that tight-toed stockings are injurious to the feet, and recommends that they be woven with a separate covering for each toe, as gloves are made with fingers.

Fig. 1 is a foot copied from the antique, and shows "beauty of form and proportion, ease and elasticity of motion, as well as an admirable expression of adaptation and power for use throughout."

Fig. 2 shows the distorted foot of a Chinese woman, photographed from nature.

Fig. 3 represents the sole of a normal human foot. The dotted line shows how the foot is usually cramped in the shoe-sole. The heel of the foot is narrow, the anterior portion broad, the toes are nearly parallel to a line "C," drawn through the center of the sole from heel to toe. The line A B is drawn through the center of the instep, or great arch of the foot, and bisects the great-toe. It is this arch which mainly supports the weight of the body; the heel forms one of its

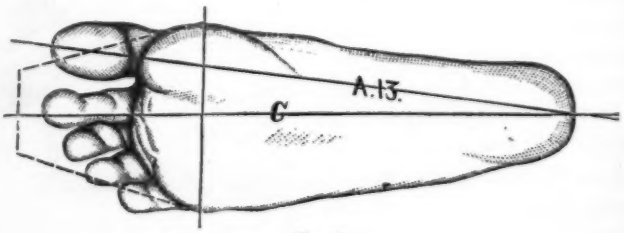

FIG. 3.

piers, the great-toe the other. One may easily see that when the great-toe is drawn from its line with the arch, as indicated by the dotted lines, the stability of the body is by so much destroyed; and when the heel is taken from its level with the bulk of the foot, by a high heel, yet more is the stability of the body destroyed. Erichson says: "Firmness of gait is caused by the foot resting on the heel be-

* The Indian moccasin is probably the easiest and most comfortable foot-covering worn, as it adapts itself perfectly to the shape and motion of the foot.

hind and the ball in front, and principally by the foot resting on the broad line formed by the great-toe and the breadth of the fore part of the foot."

The dotted lines in Fig. 3 show the outlines of a quite liberal sole. It is easy to see how an ordinary foot would be cramped if confined within its limits.

Fig. 4 shows a very common shape of the foot, produced by cramping and crowding the toes. Many persons have only to look at their own feet to see fine specimens of this sort.

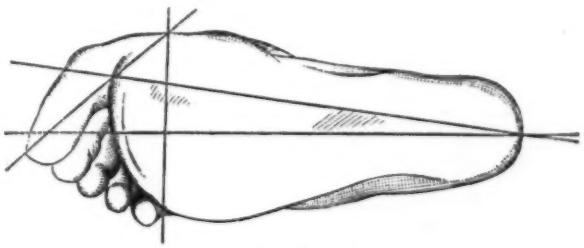

FIG 4.

The diseases most common to the feet are corns, bunyons, calluses, enlarged and stiffened joints, stiff and wasted toes, overlapping and underlapping toes, in-growing nails, caries of the bone, exostosis of the toe-bones, onyxitis of the toes, flat-foot, club-foot, ulcers, malignant and fibrous tumors, dislocations, changes in the shape of the bones from pressure, and elephantiasis. All wounds, injuries, and diseases are extremely liable to take on erysipelatous and scrofulous conditions, which speedily endanger life through their inflammatory, gangrenous, or debilitating nature; fatty degeneration of the tissues may take place, and weakness of the joints and thickening of the ankles plague their owners.

Corns consist of hardened flesh that becomes thorn-like in its shape and density, and a dismal source of pain. "A corn," says a writer, "is really a wicked demon, incarnated in a piece of callous skin. Its mission is to distress and agonize humanity and increase its wickedness." Gross says, "A bunyon is a corn on a large scale," and he and other writers agree that it is caused by a diversion of the great-toe from its line with the arch of the foot. When the toe is thus diverted, it forms an angle on the foot, which the shoe irritates and makes callous; inflammation sets in, and suppuration frequently ensues, that, in extreme cases, may make necessary amputation of the foot or feet.

Fig. 5 represents the foot of a young woman who wore high-heeled, narrow-soled shoes, which must also have been too short.

Figures 6 and 7 represent forms of bunyon complicated with under- and over-lapping toes.

Fig. 8 shows a deformity of the foot resulting from inflammation of the metatarsal, phalangeal, or great-toe joint.

Fig. 9 shows an apparatus for the cure of bunyons. Its object is to draw the great-toe back into line with the great arch of the foot.

FIG. 5.

FIG. 6.

Erichson says, bunyon is caused by improperly cut shoes, and adds that to cure it the foot should be put in a shoe cut straight from heel to toe at the inner line of the sole. The toes are naturally quite flexible. Cases are well known of men and women who, being devoid of hands or fingers, have learned to use the feet and toes instead. Miss Biffin, of London, became expert as a portrait-painter; another woman used scissors to cut out all sorts of figures from paper; and men have been fully as capable with their toes. The Chinese and Hindoos are said to be able to pick up the most delicate objects with their toes. Yet in most feet the toes are wholly incapable of independent motion, while in many feet they are entirely stiff, and are distressing objects to look at.

FIG. 7.

In-growing nails are caused by shoes which are too short, and are a source of exquisite torture. This disease may degenerate into a worse condition called onyxitis (see Fig. 10), when it discharges a fetid humor, and may render a resort to the surgeon's knife a necessity. Caries of the bone may follow wounds, bruises, contusions, bunyons, corns, and calluses of the feet; and bunyons, corns, and calluses, as well as wounds, bruises, and contusions, may take on erysipelatous, scrofulous, ulcerous, or tumorous conditions. Exostosis

of the bones (Fig. 11) is an abnormal growth which requires the saw, knife, and gouge of the surgeon for its extirpation. The toes are especially liable to this disease.

Fig. 12 is a specimen of splay or flat foot. It is caused by a breaking down of the arch of the foot, whereby locomotion becomes painful and sometimes impossible. Impairment of the general health accompanies it; in its worst forms a partial displacement of the bones occurs, the toes turn up, and the sole grows convex, while the ankle is very likely to thicken and lose strength by fatty degeneration. It is most common among youth. Some writers attribute it to "vicious eversions of the foot in attempts at polite walking"; by others it is attributed to overwork. It is most common among the children of the wealthy classes. Old people are subject to it from a breaking down of the tissues with age. For its cure local means must be used, and special attention be given to the general health.

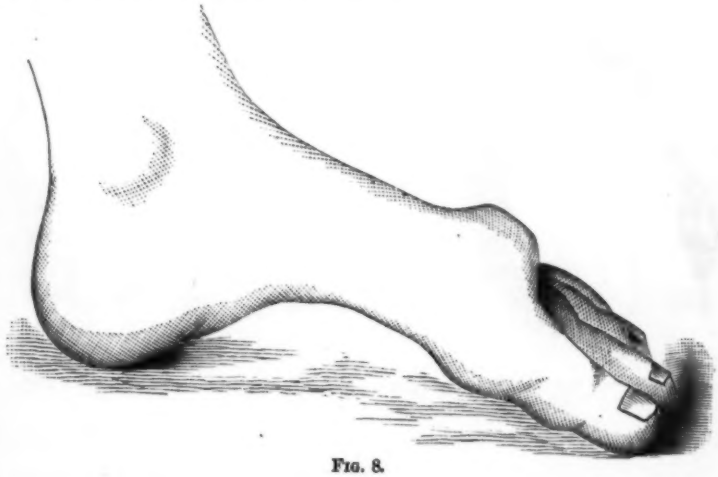

FIG. 8.

A disease called elephantiasis, sometimes necessitating amputation of the whole limb, may result from injuries to the foot. A case of this sort is found in the books, where a dislocation of the foot, caused by drawing off a boot, induced the disease.

It is now time to consider defects in shoes, by which most of these diseases may be provoked or aggravated.

Dowie, who was a practical as well as theoretical shoemaker, and so full of enthusiasm that he studied the foot under skillful anatomists, and sent all his journeymen to a course of lectures on the feet, enumerates as the principal evils, that shoes are worn too short; that they are cut too narrow at the toes and in the sole; that the soles do not conform to the shape of the inner curve of the foot, nor to the line of the great arch or instep and the great-toe; that at the waist, or middle, the sole is too stiff and unyielding; that the toe is vertically too

shallow, or "wedge-toed," as he calls it; that the heel is too high; that the sole turns up too much at the toes. He and Camper agree on these points. The evils attending shoes too short will be more readily perceived when it is understood that the foot is lengthened in walking, and more in running and jumping.

The degree of elongation depends upon the shape of the foot. Long, slim, high-arched feet elongate most; short, fleshy feet least. In the first case the elongation varies from one fourth of an inch to one inch. It takes place forward and back, and the shoe should be long enough to allow for it. It is produced by the flattening of the

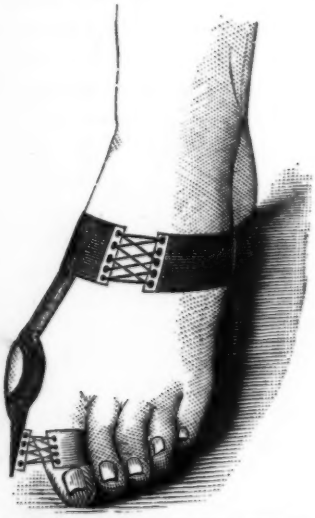

FIG. 9.—APPARATUS FOR THE TREATMENT OF BUNYONS.

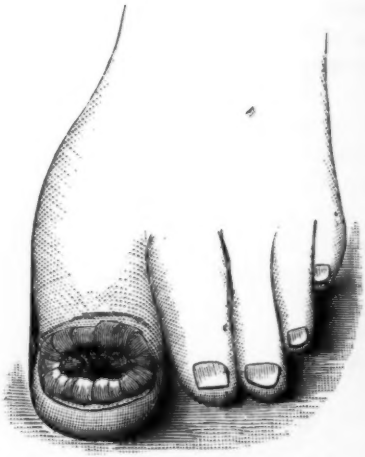

FIG. 10.—ONYXITIS OF THE GREAT TOE.

arch of the foot, when the weight of the body falls upon it; just as a carriage-spring elongates under pressure. The shoe which is just long enough when the foot is at rest, becomes too short when the elongation takes place, and the toes rise, as shown by the dotted lines in Fig. 13, preventing them from forming the firm pier which the anterior portion of the arch of the foot should have to rest upon, diminishing the elasticity of the organs, impairing their muscular force, and inducing the formation of corns through the rubbing of the toes against the leather. The weight of the body also crowds the toes up, and, turning the great-toe out of place, unfits it for its useful function. In-growing nails are caused by short shoes. An old poet says—

"The shoe too short, the foot will wring";

and an old English couplet sums up the height of aggravating misery in these lines:

"Here's to our friends; as for our foes,
We wish them *short shoes*, and corns on their toes."

Narrow-toed shoes aggravate the abnormal position of the great-toe, and cramp the other toes closely together, stopping all their free and healthful motion.

Narrow soles cramp the whole foot; calluses, corns, stiff and inelastic joints, and wasted muscles follow. The distress endured by a fleshy foot in a narrow shoe must be felt to be appreciated. If shoes are not cut "rights and lefts," they do not conform to the shape of the foot, and keep it in a continuous strain, exercising also a tendency to break down the supporting arch. The foot, thrown out of position, falls too far to one side or the other, and we have "running down at the heels," and vicious inversions of the foot in walking.

Tight shoes impede the circulation, deprive the feet of the warmth they need, and ultimately cause waste of the tissues. A friend of the writer, a strong, vigorous man, in splendid health, nearly lost his life from congestion induced by an hour's wearing of a pair of tight boots. Of shoes too stiff at the waist or middle, Dowie says, "Rigidity of this portion of the foot-covering is particularly destructive of the muscles of the foot and leg, for it interferes almost entirely with the free play of the whole foot."*

"Wedge-toed" shoes call for some preliminary remark. If one examines the ends of the fingers, it will be seen that they have a fleshy protuberance; the toes have this in common with the fingers, and its office in both is to make a soft, cushion-like protection for the bones. A wedge-toed shoe, such as is seen in Fig. 14, forces the toes immovably into a close envelope that crowds this cushion away from the bones, and wastes it to such an extent that the bones, lacking its protection, become diseased often to a degree requiring surgical treatment. The dotted lines in Fig. 14 indicate how the evil might be mitigated by giving a fullness in the upper leather. Take a round and narrow wedge-toed shoe, and let it be short as one may generally see them, worn, and you have an instrument of torture that is little short of the famous iron boot of the past ages.

Fig. 11.—Exostosis of the Bone.

"Box-toes" possessed the virtues of giving room for the extension of the foot, and saved their wearers from the torments of "wedge-toes," but they had other defects, and are now almost out of use.

High heels augment all the injuries and miseries we have enumerated. The foot on heels is in the position it occupies in going down-hill, or down the roof of a house, a most insecure and unstable one. The weight of the body is thus thrown forward, the center of gravity

* This is a prolific cause of the homely spindle-shank, which he says marks the English laborer in his wooden solid shoe. Dowie cites the Irish laborer, who goes barefoot, and has a splendid muscle in his calf, as a sample of what free play of the foot will do for the improvement of the leg.

is shifted, and the weight becomes unequally distributed among the different parts of the foot, and the forward portion has to do the bulk of the work. The inevitable detriment such a condition entails upon the health of the foot and of the body does not need to be enlarged upon. Additional inconveniences resulting from it arise from the liability of the body to fall from its unstable poise, and the propensity of the narrowly pointed heels to catch in every little crack or opening, and trip up the wearer. Of these evils the awkward, tottering gait produced by high-heeled shoes is visible evidence.

The center of gravity of the body falls directly on the angle produced by the lines A and B in Fig. 15, which shows the foot at rest in its normal position on a level surface; the line A falls inside the outline of the foot, whereby the harmonious relations of each portion of the foot are indicated. Figs. 13 and 16 represent the foot as in position upon high heels, 13 being rather exaggerated, but 16 little higher than the average heel. A glance will show that just as the heel is elevated, the line A is thrown outside of the outline of the foot, disturbing the relation of its parts, throwing the weight of the body unequally upon it, and thereby seriously interfering with its functions.

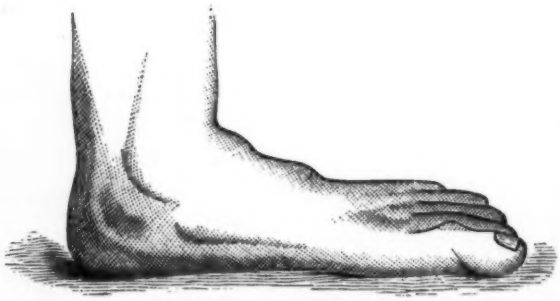

Fig. 12—Splay or Flat Foot.

There are those who believe and assert that an upright carriage of the body is assisted by high heels. A little thought and observation will convince the candid inquirer that this is a mistake. A shoemaker called my attention to the baggy trousers knees observable in connection with the wearing of high-heeled boots, and said, "Elevation of the heel thrusts the knee forward." The human body should stand erect from the heels upward, but the projection of the knee makes necessary a bending forward of the whole frame, to maintain an equilibrium. This is undoubtedly one cause of the ungraceful round shoulders and poked-forward head noticeable with so many women and girls.

The shoes of men, as a rule, are not so badly constructed and worn as the shoes of women and children. A larger proportion of men wear custom-made shoes, in which some effort is made to fit the foot. Business-men generally have eschewed heels, except the lowest "lifts."

Among soldiers and policemen, foot-soreness is a common complaint, and renders the man who has to endure it unfit for service. It is stated that, during the late East Indian wars, the native foot-soldiery, when ordered to "march," took off their regulation shoes and hung them on the ends of their muskets, while they went barefoot. Commanding officers reported great loss of men who could not keep up on account of foot-soreness, and were easily picked off by the enemy. A Highland regiment, when ordered to "charge" the foe, took off their shoes and charged barefoot, as they could do more effective work. The regulation shoes interfered with free muscular action. Dowie characterizes the shoe as a "Juggernaut of cruelty," saying it possesses wedge-toes, a rigid waist, high heels, and convex inner soles, and adds: "If a soldier be weak or lame in the feet, he can never apply with advantage the strength of his arm in charging the enemy, or in sustaining a charge, because the foot is that part of the mechanical system or leverage which rests upon the fulcrum, the ground, and, if you weaken the leverage at this important point, the strength of the whole system is reduced."

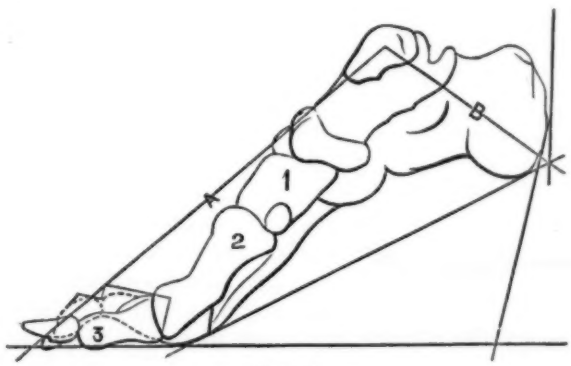

FIG. 13.

The opinions of Mr. Dowie on this subject coincide with those of eminent military men. The defects which he enumerated were common in the shoes of our own soldiery during the late war, and were followed with the same results.

It is very hard to find any woman who will confess that her shoes are too tight, too short, or too high-heeled. Her shoes are usually "miles too big," and hurt by their looseness. If women complain of lame backs or aching feet, they will be sure the shoes have no part in it; because women are really not aware how they have departed from nature in this regard. The perfect female foot is described by a physician as follows: "It should have great breadth and fullness of instep, a well-marked great-toe, a long second toe, a small little-toe." Woman needs a strong and firm footing, particularly because of her function of motherhood, and yet this perfect foot is the exact opposite of

the ideal lady's foot of to-day; narrowness, shortness, and littleness are the qualities that go to make it up; and there are women, if we may believe what is said in the newspapers, who to secure a narrow foot are willing to have the little-toe ruined.

Strange as it is, the American women, while cramping the feet, deny it. The Chinese are more logical. They distort and cripple the feminine foot to a much greater degree, and then sing its praises. Its favorite name, the "golden lily," is well known.

Many of the peculiar ailments under which women pass their days in invalidism, unhappy and miserable themselves and making others unhappy, would vanish or be greatly mitigated if they would but apply common sense to the selection of their shoes. It is very hard to persuade them to reform their habits on this point, but I have never known any woman who had learned the new comfort to go back to the old habit.

No exercise is so healthful and delightful as walking, yet few women can endure it. For to walk in their ordinary shoes is one of the most exhausting labors women can attempt. There is no doubt that by a thorough and careful system of pedestrianism many women would become robust, though now half-invalids. I know of one who walked on an average two or three miles a day, and would spend an hour or two cutting brush, saplings, and small trees, lopping off limbs, hauling brush to gullies and into heaps, and climbing fences. Her garments were warm and loose, her shoes "stogies," big, broad, and low-heeled. Health came as a reward. Another case is of a lady who is a commercial traveler in a large Western State. Her health broke with in-door confinement at school-teaching and book-keeping, and she was advised to try the road, which she did, as agent for a sash, door, and blind factory, and afterward for a paint, oil, and glass establishment. She never misses a day nor a train, dresses feet and body for comfort, is hearty and well, and earns a large salary.

FIG. 14.—A WEDGE-TOED SHOE.

The feet not only look smaller, but really become so in tight, high-heeled shoes, in consequence of a reduction of the blood-supply. We are told of a Frenchman who invented an apparatus for reducing the size of the nose, and it consisted only of a spring which cut off the supply of blood to the organ. A paper was read at a recent health congress in Switzerland, calling attention to a French style of shoe, which, the author remarked, gave the foot a "hoof-like" appearance. This style is much worn here, and produces a clumping, ungraceful jolt in the gait, tending to induce destructive spinal vibrations.

Probably the worst and most lasting injuries to the foot are produced during childhood, when the bones and cartilages are tender, and

the muscles are soft and most sensitive to strains. As a rule, children's shoes are too short and too tight, and no allowance is made in them for the growth which is all the time going on, or trying to go on, in the foot. Evidently an injury cramping the growth at this time can not be remedied; and if the children have any tendency to become bandy-legged or knock-kneed, badly shaped shoes, especially if they have high heels, will aggravate the evil and make it more lasting.

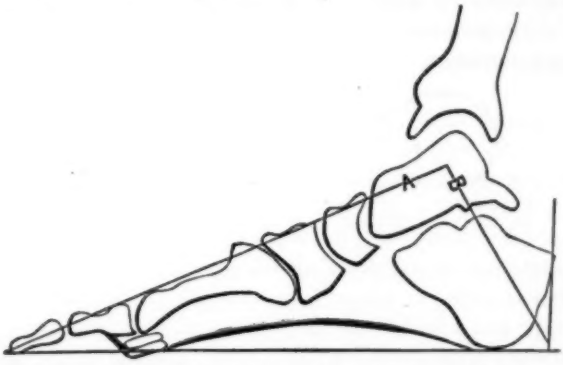

FIG. 15.—PROPER POSITION OF THE FOOT UPON THE GROUND.

André, an old French writer, is quoted by Camper as saying that high-heeled boots produce curvature of the spine in children. The shifting of the body from foot to foot to get ease contributes to this effect in one direction, and the bending forward of the body to preserve equilibrium in another, while the soft condition of the bones and muscles is a helping influence to it.

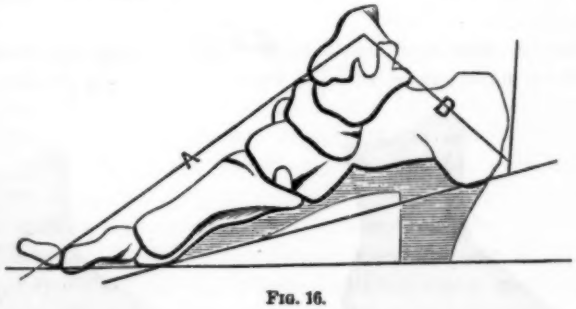

FIG. 16.

It should be remembered, too, that children suffer most from ingrowing nails caused by short shoes. Flat-foot, which is also most common among children and youth, is largely the result of convexity of the inner sole—a too common fault of children's shoes. In such shoes the center of gravity of the body is thrown out of its relations with the corresponding point in the foot, and eversions take place. The continuous strain between the foot and an improperly fitted shoe

tends to produce dislocations of the bones and to weakening of the muscles. Doubtless much of the breaking down of girls at school may be traced to some such cause as this. Boys' shoes, on the other hand, generally have low heels and broad soles, and their wearers are relieved from the special suffering which too vain mothers allow to be inflicted on the feet of their daughters.

The evils to which women are subjected from the causes we have delineated do not stop with the sufferers who induce them upon themselves, but are transmitted to their children, an inheritance of acquired weakness and suffering.

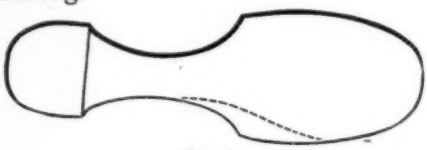

FIG. 17.

Some specimens of the shoemaker's art are shown, to illustrate how far those artists are from adapting their work to what the feet require.

Fig. 17 is the sole of an old lady's shoe, custom-made, for the wearer, suffering from constant aching feet, wanted shoes cut for ease. The heel is correctly cut, but the soles are made convex, or not curved, as the dotted line indicates they should be, to the inner curve of the foot; the toes are narrowed, or rounded, turning the great-toe inward and cramping the rest, and they allow nothing whatever for the elongation of the foot, and would look like stuffed puddings when the feet were in them. They were cut of soft kid, but, except the low heel and the soft material, they had not a single merit. They were cut in exact contrariety to the shape of the feet, and did not bring about the relief that was sought for in them.

Fig. 18 is a sample of an improved cut of shoe for women and misses. These shoes are worn by a small minority at present. They

FIG. 18.

FIG. 19.

do not altogether escape the faults of other shoes; some are wedge-toed; in others the heel is too high; and oftentimes a fault in the sole wrenches or distorts the foot. The best grades of these shoes are too high in price for other than well-to-do people to enjoy them.

Fig. 19 is a specimen of the best sort of shoe made for children, but, worn too short and too tight, it will become a means of harm to the tender foot of the child.

It is hard to understand how men and women can endure to wear the present style of pointed-toed shoes and boots. The "corn-crop" is one that never fails, and the prevalent fashion will certainly assure a yield of unusual abundance. The devotee who wore peas in his shoes for penance could make ample atonement for all his sins by simply dressing his feet according to the mode.

The whole subject is worthy of the profound study of the physician, the shoemaker, and the shoe-wearer, all of whom seem to have wickedly neglected it. If men and women, in this period of the revival of the antique, will study the natural and beautiful feet of that era, when the appreciation of physical beauty was most perfectly developed, we may hope for some not-far-distant time when our demand will be for a normal healthy foot in a natural and comfortable covering, and not for a crippled and distorted, withered, ugly "club," bound in an instrument of torment.

ON RAINBOWS.*

BY JOHN TYNDALL, F.R.S.

THE oldest historic reference to the rainbow is known to all: "I do set my bow in the cloud, and it shall be for a token of a covenant between me and the earth. . . . And the bow shall be in the cloud; and I shall look upon it, that I may remember the everlasting covenant between God and every living creature of all flesh that is upon the earth." To the sublime conceptions of the theologian succeeded the desire for exact knowledge characteristic of the man of science. Whatever its ultimate cause might have been, the proximate cause of the rainbow was physical, and the aim of science was to account for the bow on physical principles. Progress toward this consummation was very slow. Slowly the ancients mastered the principles of reflection. Still more slowly were the laws of refraction dug from the quarries in which Nature had imbedded them. I use this language because the laws were incorporate in Nature before they were discovered by man. Until the time of Alhazan, an Arabian mathematician, who lived at the beginning of the twelfth century, the views entertained regarding refraction were utterly vague and incorrect. After Alhazan came Roger Bacon and Vitellio,† who made and re-

* From author's advance sheets.

† Whewell ("History of the Inductive Sciences," vol. i, p. 345) describes Vitellio as a Pole. His mother was a Pole; but Poggendorff ("Handwörterbuch d. Exacten Wissenschaften") claims Vitellio himself as a German, born in Thüringen. "Vitellio" is described as a corruption of Witelo.

corded many observations and measurements on the subject of refraction. To them succeeded Kepler, who, taking the results tabulated by his predecessors, applied his amazing industry to extract from them their meaning—that is to say, to discover the physical principles which lay at their root. In this attempt he was less successful than in his astronomical labors. In 1604 Kepler published his "Supplement to Vitellio," in which he virtually acknowledged his defeat, by enunciating an approximate rule, instead of an all-satisfying natural law. The discovery of such a law, which constitutes one of the chief corner-stones of optical science, was made by Willebrord Snell, about 1621.*

A ray of light may, for our purposes, be presented to the mind as a luminous straight line. Let such a ray be supposed to fall vertically upon a perfectly calm water-surface. The incidence, as it is called, is then perpendicular, and the ray goes through the water without deviation to the right or left. In other words, the ray in the air and the ray in the water form one continuous straight line. But the least deviation from the perpendicular causes the ray to be broken, or "refracted," at the point of incidence. What, then, is the law of refraction discovered by Snell? It is this, that no matter how the angle of incidence, and with it the angle of refraction, may vary, the relative magnitude of two lines, dependent on these angles, and called their sines, remains, for the same medium, perfectly unchanged. Measure, in other words, for various angles, each of these two lines with a scale, and divide the length of the longer one by that of the shorter; then, however the lines individually vary in length, the quotient yielded by this division remains absolutely the same. It is, in fact, what is called the index of refraction of the medium.

Science is an organic growth, and accurate measurements give coherence to the scientific organism. Were it not for the antecedent discovery of the law of sines, founded as it was on exact measurements, the rainbow could not have been explained. Again and again, moreover, the angular distance of the rainbow from the sun had been determined and found constant. In this divine remembrancer there was no variableness. A line drawn from the sun to the rainbow, and another drawn from the rainbow to the observer's eye, always inclosed an angle of 41°. Whence this steadfastness of position—this inflexible adherence to a particular angle? Newton gave to De Dominis† the credit of the answer; but we really owe it to the genius of Descartes. He followed with his mind's eye the rays of light impinging on a rain-drop. He saw them in part reflected from the outside surface of the drop. He saw them refracted on entering the drop, reflected

* Born at Leyden 1591; died 1626.

† Archbishop of Spalatro, and Primate of Dalmatia. Fled to England about 1616; became a Protestant, and was made Dean of Windsor. Returned to Italy and resumed his Catholicism; but was handed over to the Inquisition, and died in prison (Poggendorff's "Biographical Dictionary").

from its back, and again refracted on their emergence. Descartes was acquainted with the law of Snell, and, taking up his pen, he calculated, by means of that law, the whole course of the rays. He proved that the vast majority of them escaped from the drop as *divergent* rays, and, on this account, soon became so enfeebled as to produce no sensible effect upon the eye of an observer. At one particular angle, however—namely, the angle 41° aforesaid—they emerged in a practically parallel sheaf. In their union was strength, for it was this particular sheaf which carried the light of the "primary" rainbow to the eye.

There is a certain form of emotion called intellectual pleasure, which may be excited by poetry, literature, nature, or art. But I doubt whether among the pleasures of the intellect there is any more pure and concentrated than that experienced by the scientific man when a difficulty which has challenged the human mind for ages melts before his eyes, and recrystallizes as an illustration of natural law. This pleasure was doubtless experienced by Descartes when he succeeded in placing upon its true physical basis the most splendid meteor of our atmosphere. Descartes showed, moreover, that the "secondary bow" was produced when the rays of light underwent two reflections within the drop, and two refractions at the points of incidence and emergence.

It is said that Descartes behaved ungenerously to Snell—that, though acquainted with the unpublished papers of the learned Dutchman, he failed to acknowledge his indebtedness. On this I will not dwell, for I notice on the part of the public a tendency, at all events in some cases, to emphasize such short-comings. The temporary weakness of a great man is often taken as a sample of his whole character. The spot upon the sun usurps the place of his "surpassing glory." This is not unfrequent, but it is nevertheless unfair.

Descartes proved that, according to the principles of refraction, a circular band of light must appear in the heavens exactly where the rainbow is seen. But how are the colors of the bow to be accounted for? Here his penetrative mind came to the very verge of the solution, but the limits of knowledge at the time barred his further progress. He connected the colors of the rainbow with those produced by a prism; but then these latter needed explanation just as much as the colors of the bow itself. The solution, indeed, was not possible until the composite nature of white light had been demonstrated by Newton. Applying the law of Snell to the different colors of the spectrum, Newton proved that the primary bow must consist of a series of concentric circular bands, the largest of which is red, and the smallest violet; while in the secondary bow these colors must be reversed. The main secret of the rainbow, if I may use such language, was thus revealed.

I have said that each color of the rainbow is carried to the eye by

a sheaf of approximately parallel rays. But what determines this parallelism? Here our real difficulties begin, but they are to be surmounted by attention. Let us endeavor to follow the course of the solar rays before and after they impinge upon a spherical drop of water. Take first of all the ray that passes through the center of the drop. This particular ray strikes the back of the drop as a perpendicular, its reflected portion returning along its own course. Take another ray close to this central one and parallel to it—for the sun's rays when they reach the earth are parallel. When this second ray enters the drop it is refracted; on reaching the back of the drop it is there reflected, being a second time refracted on its emergence from the drop. Here the incident and the emergent rays inclose a small angle with each other. Take again a third ray a little farther from the central one than the last. The drop will act upon it as it acted upon its neighbor, the incident and emergent rays inclosing in this instance a larger angle than before. As we retreat farther from the central ray the enlargement of this angle continues up to a certain point, where it reaches a maximum, after which further retreat from the central ray diminishes the angle. Now, a maximum resembles the ridge of a hill, or a water-shed, from which the land falls in a slope at each side. In the case before us the divergence of the rays when they quit the rain-drop would be represented by the steepness of the slope. On the top of the water-shed—that is to say, in the neighborhood of our maximum—is a kind of summit level, where the slope for some distance almost disappears. But the disappearance of the slope indicates, in the case of our rain-drop, the absence of divergence. Hence we find that at our maximum, and close to it, there issues from the drop a sheaf of rays which are nearly, if not quite, parallel to each other. These are the so-called "effective rays" of the rainbow.*

Let me here point to a series of measurements which will illustrate the gradual augmentation of the deflection just referred to until it reaches its maximum, and its gradual diminution at the other side of the maximum. The measures correspond to a series of angles of incidence which augment by steps of ten degrees:

i	*d*	*i*	*d*
10°	10°	60°	42° 28′
20°	19° 36′	70°	39° 48′
30°	28° 20′	80°	31° 4′
40°	35° 36′	90°	15
50°	40° 40′		

The figures in the column *i* express these angles, while under *d* we have in each case the accompanying deviation, or the angle inclosed

* There is, in fact, a bundle of rays near the maximum, which, when they enter the drop, are converged by refraction almost exactly to the same point at its back. If the convergence were *quite* exact, then the symmetry of the liquid sphere would cause the rays to quit the drop as they entered it—that is to say, perfectly parallel. But inasmuch

by the incident and emergent rays. It will be seen that as the angle i increases, the deviation also increases up to 42° 28′, after which, although the angle of incidence goes on augmenting, the deviation becomes less. The maximum 42° 28′ corresponds to an incidence of 60°, but in reality at this point we have already passed, by a small quantity, the exact maximum, which occurs between 58° and 59°. Its amount is 42° 30′. This deviation corresponds to the red band of the rainbow. In a precisely similar manner the other colors rise to their maximum, and fall on passing beyond it; the maximum for the violet band being 40° 30′. The entire width of the primary rainbow is therefore 2°, part of this width being due to the angular magnitude of the sun.

We have thus revealed to us the geometric construction of the rainbow. But though the step here taken by Descartes and Newton was a great one, it left the theory of the bow incomplete. Within the rainbow proper, in certain conditions of the atmosphere, are seen a series of richly-colored zones, which were not explained by either Descartes or Newton. They are said to have been first described by Mariotte,* and they long challenged explanation. At this point our difficulties thicken, but, as before, they are to be overcome by attention. It belongs to the very essence of a maximum, approached continuously on both sides, that on the two sides of it pairs of equal value may be found. The maximum density of water, for example, is 39° Fahr. Its density when 5° colder, and when 5° warmer, than this maximum is the same. So, also, with regard to the slopes of our water-shed. A series of pairs of points of the same elevation can be found upon the two sides of the ridge; and, in the case of the rainbow, on the two sides of the maximum deviation we have a succession of pairs of rays having the same deflection. Such rays travel along the same line, and add their forces together after they quit the drop. But light, thus re-enforced by the coalescence of non-divergent rays, ought to reach the eye. It does so; and were light what it was once supposed to be—a flight of minute particles sent by luminous bodies through space—then these pairs of equally deflected rays would diffuse brightness over a large portion of the area within the primary bow. But inasmuch as light consists of waves and not of particles, the principle of interference comes into play, in virtue of which waves can alternately re-enforce and destroy each other. Were the distance passed over, by the two corresponding rays within the drop, the same, they would emerge exactly as they entered. But in no case are the

as the convergence is not quite exact, the parallelism after emergence is only approximate. The emergent rays cut each other at extremely sharp angles, thus forming a "caustic" which has for its asymptote the ray of maximum deviation In the secondary bow we have to deal with a minimum, instead of a maximum, the crossing of the incident and emergent rays producing the observed reversal of the colors. (See Engel and Shellbach's diagrams of the rainbow.)

* Prior of St. Martin-sous-Beaune, near Dijon, member of the French Academy of Sciences; died in Paris, May, 1684.

distances the same. The consequence is that when the rays emerge from the drop they are in a condition either to support or to destroy each other. By such alternate re-enforcement and destruction, the colored zones are produced within the primary bow. They are called "supernumerary bows," and are seen not only within the primary but sometimes also outside the secondary bow. The condition requisite for their production is, that the drops which constitute the shower shall all be of nearly the same size. When the drops are of different sizes, we have a confused superposition of the different colors, an approximation to white light being the consequence. This second step in the explanation of the rainbow was taken by a man the quality of whose genius resembled that of Descartes or Newton, and who eighty-two years ago was appointed Professor of Natural Philosophy in the Royal Institution of Great Britain. I refer, of course, to the illustrious Thomas Young.*

But our task is not, even now, complete. The finishing touch to the explanation of the rainbow was given by our last, eminent, Astronomer Royal, Sir George Airy. Bringing the knowledge possessed by the founders of the undulatory theory, and that gained by subsequent workers to bear upon the question, Sir George Airy showed that, though Young's general principles were unassailable, his calculations were sometimes wide of the mark. It was proved by Airy that the curve of maximum illumination in the rainbow does not quite coincide with the geometric curve of Descartes and Newton. He also extended our knowledge of the supernumerary bows, and corrected the positions which Young had assigned to them. Finally, Professor Miller, of Cambridge, and Dr. Galle, of Berlin, illustrated by careful measurements with the theodolite the agreement which exists between the theory of Airy and the facts of observation. Thus, from Descartes to Airy, the intellectual force expended in the elucidation of the rainbow, though broken up into distinct personalities, might be regarded as that of an individual artist engaged throughout this time in lovingly contemplating, revising, and perfecting his work.

We have thus cleared the ground for the series of experiments which constitute the subject of this discourse. During our brief residence in the Alps this year, we were favored with some weather of matchless perfection; but we had also our share of foggy and drizzly weather. On the night of the 22d of September, the atmosphere was especially dark and thick. At 9 P. M. I opened a door at the end of a passage and looked out into the gloom. Behind me hung a small lamp, by which the shadow of my body was cast upon the fog. Such a shadow I had often seen, but in the present case it was accompanied by an appearance which I had not previously seen. Swept through the darkness round the shadow, and far beyond, not only its boundary,

* Young's works, edited by Peacock, vol. i, pp. 185, 293, 357.

but also beyond that of the illuminated fog, was a pale, white, luminous circle, complete except at the point where it was cut through by the shadow. As I walked out into the fog, this curious halo went in advance of me. Had not my demerits been so well known to me, I might have accepted the phenomenon as an evidence of canonization. Benvenuto Cellini saw something of the kind surrounding his shadow, and ascribed it forthwith to supernatural favor. I varied the position and intensity of the lamp, and found even a candle sufficient to render the luminous band visible. With two crossed laths I roughly measured the angle subtended by the radius of the circle, and found it to be practically the angle which had riveted the attention of Descartes —namely, 41°. This and other facts led me to suspect that the halo was a circular rainbow. A week subsequently, the air being in a similar misty condition, the luminous circle was well seen from another door, the lamp which produced it standing on a table behind me.

It is not, however, necessary to go to the Alps to witness this singular phenomenon. Amid the heather of Hind Head I have had erected a hut, to which I escape when my brain needs rest or my muscles lack vigor. The hut has two doors, one opening to the north and the other to the south, and in it we have been able to occupy ourselves pleasantly and profitably during the recent misty weather. Removing the shade from a small petroleum-lamp, and placing the lamp behind me, as I stood in either doorway, the luminous circles surrounding my shadow on different nights were very remarkable. Sometimes they were best to the north, and sometimes the reverse, the difference depending for the most part on the direction of the wind. On Christmas-night the atmosphere was particularly good-natured. It was filled with true fog, through which, however, descended palpably an extremely fine rain. Both to the north and to the south of the hut the luminous circles were on this occasion specially bright and well-defined. They were, as I have said, swept through the fog far beyond its illuminated area, and it was the darkness against which they were projected which enabled them to shed so much apparent light. The "effective rays," therefore, which entered the eye in this observation gave direction, but not distance, so that the circles appeared to come from a portion of the atmosphere which had nothing to do with their production. When the lamp was taken out into the fog, the illumination of the medium almost obliterated the halo. Once educated, the eye could trace it, but it was toned down almost to vanishing. There is some advantage, therefore, in possessing a hut, on a moor or on a mountain, having doors which limit the area of fog illuminated.

I have now to refer to another phenomenon which is but rarely seen, and which I had an opportunity of witnessing on Christmas-day. The mist and drizzle in the early morning had been very dense ; a walk before breakfast caused my somewhat fluffy pilot dress to be covered with minute water-globules, which, against the dark background under-

neath, suggested the bloom of a plum. As the day advanced, the southeastern heaven became more luminous, and the pale disk of the sun was at length seen struggling through drifting clouds. At ten o'clock the sun had become fairly victorious, the heather was adorned by pendent drops, while certain branching grasses, laden with liquid pearls, presented, in the sunlight, an appearance of exquisite beauty. Walking across the common to the Portsmouth road, my wife and I, on reaching it, turned our faces sunward. The smoke-like fog had vanished, but its disappearance was accompanied, or perhaps caused, by the coalescence of its minuter particles into little globules, visible where they caught the light at a proper angle, but not otherwise. They followed every eddy of the air, upward, downward, and from side to side. Their extreme mobility was well calculated to suggest a notion prevalent on the Continent, that the particles of a fog, instead of being full droplets, are really little bladders or vesicles. Clouds are supposed to owe their power of floatation to this cause. This vesicular theory never struck root in England ; nor has it, I apprehend, any foundation in fact.

As I stood in the midst of these eddying specks, so visible to the eye, yet so small and light as to be perfectly impalpable to the skin both of hands and face, I remarked, "These particles must surely yield a bow of some kind." Turning my back to the sun, I stooped down so as to keep well within the layer of particles, which I supposed to be a shallow one, and looking toward the "Devil's Punch-Bowl," saw the anticipated phenomenon. A bow without color spanned the Punch-Bowl, and, though white and pale, was well defined and exhibited an aspect of weird grandeur. Once or twice I fancied a faint ruddiness could be discerned on its outer boundary. The stooping was not necessary, and as we walked along the new Portsmouth road, with the Punch-Bowl to our left, the white arch marched along with us. At a certain point we ascended to the old Portsmouth road, whence, with a flat space of very dark heather in the foreground, we watched the bow. The sun had then become strong, and the sky above us blue, nothing which could in any proper sense be called rain existing at the time in the atmosphere. Suddenly my companion exclaimed, "I see the whole circle meeting at my feet!" At the same moment the circle became visible to me also. It was the darkness of our immediate foreground that enabled us to see the pale, luminous band projected against it. We walked round Hind Head Common with the bow almost always in view. Its crown sometimes disappeared, showing that the minute globules which produced it did not extend to any great height in the atmosphere. In such cases, two shining buttresses were left behind, which, had not the bow been previously seen, would have lacked all significance. In some of the combes, or valleys, where the floating particles had collected in greater numbers, the end of the bow plunging into the combe emitted a light of more than the usual brightness.

During our walk the bow was broken and reformed several times, and, had it not been for our previous experience, both in the Alps and at Hind Head, it might well have escaped attention. What this white bow lost in beauty and intensity, as compared with the ordinary colored bow, was more than atoned for by its weirdness and its novelty to both observers.

The white rainbow (*l'arc en ciel blanc*) was first described by the Spaniard, Don Antonio de Ulloa, Lieutenant of the Company of Gentlemen Guards of the Marine. By order of the King of Spain, Don Jorge Juan and Ulloa made an expedition to South America, an account of which is given in two amply-illustrated quarto volumes to be found in the library of the Royal Institution. The bow was observed from the summit of the mountain Pambamarca, in Peru. The angle subtended by its radius was 33° 30′, which is considerably less than the angle subtended by the radius of the ordinary bow. Between the phenomenon observed by us on Christmas-day, and that described by Ulloa, there are some points of difference. In his case fog of sufficient density existed to enable the shadows of him and his six companions to be seen, each, however, only by the person whose body cast the shadow, while around the head of each were observed those zones of color which characterize the "specter of the Brocken." In our case no shadows were to be seen, for there was no fog-screen on which they could be cast. This implies also the absence of the zones of color observed by Ulloa.

The white rainbow has been explained in various ways. A learned Frenchman, M. Bravais, who has written much on the optical phenomena of the atmosphere, and who can claim the additional recommendation of being a distinguished mountaineer, has sought to connect the bow with the vesicular theory to which I have just referred. This theory, however, is more than doubtful, and it is not necessary.* The genius of Thomas Young throws light upon this subject as upon so many others. He showed that the whiteness of the bow was a direct consequence of the smallness of the drops which produce it. In fact, the wafted water-specks seen by us upon Hind Head † were the very kind needed for the production of the phenomenon. But the observations of Ulloa place his white bow distinctly *within* the arc that would be occupied by the ordinary rainbow—that is to say, in the region of supernumeraries; and by the action of the supernumeraries upon each other Ulloa's bow was accounted for by Thomas Young. The smaller

* The vesicular theory was combated very ably in France by the Abbé Raillard, who has also given an interesting analysis of the rainbow at the end of his translation of my "Notes on Light."

† Had our refuge in the Alps been built on the southern side of the valley of the Rhône, so as to enable us to look with the sun behind us into the valley and across it, we should, I think, have frequently seen the white bow; whereas on the opposite mountain-slope, which faces the sun, we have never seen it.

the drops the broader are the zones of the supernumerary bows, and Young proved by calculation that when the drops have a diameter of $\frac{1}{3000}$ or $\frac{1}{4000}$ of an inch, the bands overlap each other, and produce white light by their mixture. Unlike the geometric bow, the radius of the white bow varies within certain limits, which M. Bravais shows to be 33° 30′ and 41° 46′ respectively. In the latter case the white bow is the ordinary bow deprived of its color by the smallness of the drops. In all the other cases it is produced by the action of the supernumeraries.

The physical investigator desires not only to observe natural phenomena but to recreate them—to bring them, that is, under the dominion of experiment. From observation we learn what Nature is willing to reveal. In experimenting we place her in the witness-box, cross-examine her, and extract from her knowledge in excess of that which would, or could, be spontaneously given. Accordingly, on my return from Switzerland last October, I sought to reproduce in the laboratory the effects observed among the mountains. My first object, therefore, was to obtain artificially a mixture of fog and drizzle like that observed from the door of our cottage. A strong cylindrical copper boiler, sixteen inches high and twelve inches in diameter, was nearly filled with water, and heated by gas-flames until steam of twenty pounds pressure was produced. A valve at the top of the boiler was then opened, when the steam issued violently into the atmosphere, carrying droplets of water mechanically along with it, and condensing above to droplets of a similar kind. A fair imitation of the Alpine atmosphere was thus produced. After a few tentative experiments, the luminous circle was brought into view, and, having once got hold of it, the next step was to enhance its intensity. Oil-lamps, the lime-light, and the naked electric light were tried in succession, the source of rays being placed in one room, the boiler in another, while the observer stood, with his back to the light, between them. It is not, however, necessary to dwell upon these first experiments, surpassed as they were by the arrangements subsequently adopted. My mode of proceeding was this: The electric light being placed in a camera with a condensing lens in front, the position of the lens was so fixed as to produce a beam sufficiently broad to clasp the whole of my head, and leave an aureole of light around it. It being desirable to lessen as much as possible the foreign light entering the eye, the beam was received upon a distant black surface, and it was easy to move the head until its shadow occupied the center of the illuminated area. To secure the best effect it was found necessary to stand close to the boiler, so as to be immersed in the fog and drizzle. The fog, however, was soon discovered to be a mere nuisance. Instead of enhancing, it blurred the effect, and I therefore sought to abolish it. Allowing the steam to issue for a few seconds from the boiler, on closing the valve, the cloud rapidly melted away, leaving behind it a host of minute

liquid spherules floating in the beam. A beautiful circular rainbow was instantly swept through the air in front of the observer. The primary bow was duly attended by its secondary, with the colors, as usual, reversed. The opening of the valve for a single second causes the bows to flash forth. Thus, twenty times in succession, puffs can be allowed to issue from the boiler, every puff being followed by this beautiful meteor. The bows produced by single puffs are evanescent, because the little globules rapidly disappear. Greater permanence is secured when the valve is left open for an interval sufficient to discharge a copious amount of drizzle into the air.*

Many other appliances for producing a fine rain have been tried, but a reference to two of them will suffice. The rose of a watering-pot naturally suggests a means of producing a shower; and on the principle of the rose I had some spray-producers constructed. In each case the outer surface was convex, the thin convex metal plate being pierced by orifices too small to be seen by the naked eye. Small as they are, fillets of very sensible magnitude issue from the orifices, but at some distance below the spray-producer the fillets shake themselves asunder and form a fine rain. The small orifices are very liable to get clogged by the fine particles suspended in London water. In experiments with the rose, filtered water was, therefore, resorted to. A large vessel was mounted on the roof of the Royal Institution, from the bottom of which descended vertically a piece of compo-tubing, an inch in diameter and about twenty feet long. By means of proper screw fittings, a single rose, or, when it is desired to increase the magnitude or density of the shower, a group of two, three, or four roses, is attached to the end of the compo-tube. From these, on the turning on of a cock, the rain descends. The circular bows produced by such rain are far richer in color than those produced by the smaller globules of the condensed steam. To see the effect in all its beauty and completeness, it is necessary to stand well within the shower, not outside of it. A water-proof coat and cap are, therefore, needed, to which a pair of goloshes may be added with advantage. A person standing outside the beam may see bits of both primary and secondary in the places fixed by their respective angles; but the colors are washy and unimpressive, while within the shower, with the shadow of the head occupying its proper position on the screen, the brilliancy of the effect is extraordinary. The primary clothes itself in the richest

* It is perhaps worth noting here, that when the camera and lens are used the beam which sends its "effective rays" to the eye may not be more than a foot in width, while the circular bow engendered by these rays may be, to all appearance, fifteen or twenty feet in diameter. In such a beam, indeed, the drops which produce the bow must be very near the eye, for rays from the more distant drops would not reach the required angle. The apparent distance of the circular bow is often great, in comparison with that of the originating drops. Both distance and diameter may be made to undergo variations. In the rainbow we do not see a localized object, but receive a luminous impression, which is often transferred to a portion of the field of view far removed from the bow's origin.

tints, while the secondary, though less vivid, shows its colors in surprising strength and purity.

But the primary bow is accompanied by appearances calculated to attract and rivet attention almost more than the bow itself. I have already mentioned the existence of effective rays over and above those which go to form the geometric law. They fall within the primary, and, to use the words of Thomas Young, "would exhibit a continued diffusion of fainter light, but for the general law of interference which divides the light into concentric rings." One could almost wish for the opportunity of showing Young how literally his words are fulfilled, and how beautifully his theory is illustrated, by these artificial circular rainbows. For here the space within the primaries is swept by concentric supernumerary bands, colored like the rainbow, and growing gradually narrower as they retreat from the primary. These spurious bows as they are sometimes called,* which constitute one of the most splendid illustrations of the principle of interference, are separated from each other by zones of darkness, where the light-waves, on being added together, destroy each other. I have counted as many as eight of these beautiful bands, concentric with the true primary. The supernumeraries are formed next to the most refrangible color of the bow, and therefore occur *within* the primary circle. But, in the secondary bow, the violet, or most refrangible color, is on the *outside;* and, following the violet of the secondary, I have sometimes counted as many as five spurious bows. Some notion may be formed of the intensity of the primary, when the secondary is able to produce effects of this description.

An extremely handy spray-producer is that employed to moisten the air in the Houses of Parliament. A fillet of water, issuing under strong pressure from a small orifice, impinges on a little disk, placed at a distance of about one twentieth of an inch from the orifice. On striking the disk, the water spreads laterally, and breaks up into exceedingly fine spray. Here, also, I have used the spray-producer both singly and in groups, the latter arrangement being resorted to when showers of special density were required. In regard to primaries, secondaries, and supernumeraries, extremely brilliant effects have been obtained with this form of spray-producer. The quantity of water called upon being much less than that required by the rose, the fillet-and-disk instrument produces less flooding of the locality where the experiments are made. In this latter respect, the steam-spray is particularly handy. A puff of two seconds' duration suffices to bring out the bows, the subsequent shower being so light as to render the use of water-proof clothing unnecessary. In other cases, the inconvenience of flooding may be avoided to a great extent by turning on the spray for a short time only, and then cutting off the supply of water. The vision of the bow being, however, proportionate to the

* A term, I confess, not to my liking.

duration of the shower, will, when the shower is brief, be evanescent. Hence, when quiet and continued contemplation of all the phenomena is desired, the observer must make up his mind to brave the rain.*

In one important particular the spray-producer last described commends itself to our attention. With it we can operate on substances more costly than water, and obtain rainbows from liquids of the most various refractive indices. To extend the field of experiment in this direction, the following arrangement has been devised: A strong cylindrical iron bottle, wholly or partly filled with the liquid to be experimented on, is tightly closed by a brass cap. Through the cap passes a metal tube, soldered air-tight where it crosses the cap, and ending near the bottom of the iron bottle. To the free end of this tube is attached the spray-producer. A second tube passes also through the cap, but ends above the surface of the liquid. This second tube, which is long and flexible, is connected with a larger iron bottle, containing compressed air. Hoisting the small bottle to a convenient height, the tap of the larger bottle is carefully opened, the air passes through the flexible tube to the smaller bottle, exerts its pressure upon the surface of the liquid therein contained, drives it up the other tube, and causes it to impinge with any required degree of force against the disk of the spray-producer. From this it falls in a fine rain. A great many liquids have been tested by this arrangement, and very remarkable results have been obtained. I will confine myself here to a reference to two liquids, which commend themselves on account of their cheapness and of the brilliancy of their effects. Spirit of turpentine, forced from the iron bottle, and caused to fall in a fine shower, produces a circular bow of extraordinary intensity and depth of color. With paraffine-oil or petroleum a similar effect is obtained.

Spectrum analysis, as generally understood, occupies itself with atomic, or molecular, action, but physical spectrum analysis may be brought to bear upon our falling showers. I asked myself whether a composite shower—that is to say, one produced by the mingled spray of two or more liquids—could not be analyzed and made to declare its constituents by the production of the circular rainbows proper to the respective liquids. This was found to be the case. In the ordinary rainbow the narrowest color-band is produced by its most refrangible light. In general, the greater the refraction, the smaller will be the bow. Now, as spirit of turpentine and paraffine are both more refractive than water, I thought it probable that in a mixed shower of water and paraffine, or water and turpentine, the smaller and more luminous circle of the latter ought to be seen within the larger circle of the former. The result was exactly in accordance with this anticipation. Beginning with water, and producing its two bows, and then allowing the turpentine to shower down and mingle with the water, within the

* The rays which form the artificial bow emerge, as might be expected, polarized from the drops.

large and beautifully colored water-wheel, the more richly colored circle of the turpentine makes its appearance. Or, beginning with turpentine, and forming its concentrated iris; on turning on the water-spray, though to the eye the shower seems absolutely homogeneous, its true character is instantly declared by the flashing out of the larger concentric aqueous bow. The water primary is accompanied by its secondary close at hand. Associated, moreover, with all the bows, primary and secondary, are the supernumeraries which belong to them; and a more superb experimental illustration of optical principles it would be hardly possible to witness. It is not the less impressive because extracted from the simple combination of a beam of light and a shower of rain.

In the "Philosophical Transactions" for 1835, the late Colonel Sykes gave a vivid description of a circular solar rainbow, observed by him in India, during periods when fogs and mists were prevalent in the chasms of the Ghâts of the Deccan:

It was during such periods that I had several opportunities of witnessing that singular phenomenon, the circular rainbow, which, from its rareness, is spoken of as a possible occurrence only. The stratum of fog from the Konkun on some occasions rose somewhat above the level of the top of a precipice forming the northwest scarp of the hill fort of Hurreechundurghur, from two to three thousand feet perpendicular, without coming over upon the table-land. I was placed at the edge of the precipice just without the limits of the fog, and with a cloudless sun at my back at a very low elevation. Under such a combination of favorable circumstances, the circular rainbow appeared quite perfect, of the most vivid colors, one half above the level on which I stood, the other half below it. Shadows in distinct outline of myself, my horse, and people appeared in the center of the circle as a picture, to which the bow formed a resplendent frame. My attendants were incredulous that the figures they saw under such extraordinary circumstances could be their own shadows, and they tossed their arms and legs about, and put their bodies into various postures, to be assured of the fact by the corresponding movements of the objects within the circle; and it was some little time ere the superstitious feeling with which the spectacle was viewed wore off. From our proximity to the fog, I believe the diameter of the circle at no time exceeded fifty or sixty feet. The brilliant circle was accompanied by the usual outer bow in fainter colors.

Mr. E. Colborne Baber, an accomplished and intrepid traveler, has recently enriched the "Transactions" of the Royal Geographical Society by a paper of rare merit, in which his travels in Western China are described. He made there the ascent of Mount O—an eminence of great celebrity. Its height is about eleven thousand feet above the sea, and it is flanked on one side by a cliff "a good deal more than a mile in height." From the edge of this cliff, which is guarded by posts and chains, you look into an abyss, and if fortune, or rather the mists, favor you, you see there a miracle, which is thus described by Mr. Baber:

Naturally enough it is with some trepidation that pilgrims approach this fear-

some brink, but they are drawn to it by the hope of beholding the mysterious apparition known as the "Fo-Kuang," or "Glory of Buddha," which floats in mid-air, half-way down. So many eye-witnesses had told me of this wonder, that I could not doubt; but I gazed long and steadfastly into the gulf without success, and came away disappointed, but not incredulous. It was described to me as a circle of brilliant and many-colored radiance, broken on the outside with quick flashes and surrounding a central disk as bright as the sun, but more beautiful. Devout Buddhists assert that it is an emanation from the aureole of Buddha, and a visible sign of the holiness of Mount O.

Impossible as it may be deemed, the phenomenon does really exist. I suppose no better evidence could be desired for the attestation of a Buddhist miracle than that of a Baptist missionary, unless, indeed, it be, as in this case, that of *two* Baptist missionaries. Two gentlemen of that persuasion have ascended the mountain since my visit, and have seen the Glory of Buddha several times. They relate that it resembles a golden sun-like disk, inclosed in a ring of prismatic colors more closely blended than in the rainbow. . . . The missionaries inform me that it was about three o'clock in the afternoon, near the middle of August, when they saw the meteor, and that it was only visible when the precipice was more or less clothed in mist. It appeared to lie on the surface of the mist, and was always in the direction of a line drawn from the sun through their heads, as is certified by the fact that the shadow of their heads was seen on the meteor. They could get their heads out of the way, so to speak, by stooping down, but are not sure if they could do so by stepping aside. Each spectator, however, could see the shadows of the by-standers as well as his own projected on to the appearance. They did not observe any rays spreading from it. The central disk, they think, is a reflected image of the sun, and the inclosing ring is a rainbow. The ring was in thickness about one fourth of the diameter of the disk, and distant from it by about the same extent; but the recollection of one informant was that the ring touched the disk, without any intervening space. The shadow of a head, when thrown upon it, covered about one eighth of the whole diameter of the meteor. The rainbow ring was not quite complete in its lower part, but they attribute this to the interposition of the edge of the precipice. They see no reason why the appearance should not be visible at night when the moon is brilliant and appositely placed. They profess themselves to have been a good deal surprised, but not startled, by the spectacle. They would consider it remarkable rather than astonishing, and are disposed to call it a very impressive phenomenon.

It is to be regretted that Mr. Baber failed to see the "Glory," and that we in consequence miss his own description of it. There seems a slight inadvertence in the statement that the head could be got out of the way by stooping; for, as long as the "Glory" remained a circle, the shadow of the head must have occupied its center. Stepping aside would simply displace the bow, but not abolish the shadow.

Thus, starting from the first faint circle seen drawn through the thick darkness at Alp Lusgen, we have steadily followed and developed our phenomenon, and ended by rendering the "Glory of Buddha" a captive of the laboratory. The result might be taken as typical of larger things.

SCIENCE *VERSUS* THE CLASSICS.

By C. A. EGGERT,
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AT the present stage of the discussion as to the value of the training in the Latin and Greek languages and their literature, the testimony of Professor Preyer, of the University of Jena, is not without importance. Professor Preyer is interested, and he not alone among German professors, in the question of "health and vigor *versus* disease and weakness" of the German youth. In an article "On the Preservation of Health," published in the "Deutsche Rundschau," he made the following pertinent remarks:

"The preservation of health, of the power of sight and muscle, of the readiness of the mind to receive impressions from nature and man, of freshness and youthful elasticity, is undoubtedly of much more consequence for the age of our graduates than a knowledge, no matter how thorough, of history and the dead languages. A first-class German college (gymnasium) requires at present the reading of Sophocles, Homer, Thucydides, Demosthenes, Plutarch, Herodotus, Xenophon, Tacitus, Horace, Cæsar, Cicero, Livy, Virgil, Sallust, Ovid, and I find among its text-books Greek, Latin, and Hebrew grammars, a Latin phrase-book, an ecclesiastical history, and several other books, which, to be understood, require an amount of brain-work out of proportion to the results obtained. I find there the very same Latin and Greek authors which I read myself at school some twenty-four to twenty-eight years ago. The *present stand-point of the humanistic gymnasia is*, in spite of some attempts at adaptation to the new time, *essentially the mediæval one*, which was justifiable several centuries ago, because there was then nothing better than the ancient classics, and particularly no exact natural science, to furnish means of discipline. *At present, however, there are many books which, both as regards form and contents, are better fitted for* the instruction of young people than the authors enumerated. Why are not extracts read from the writings of Galilei, Descartes, Newton, Bacon, Faraday, Luther, Harvey, Frederick the Great, Leibnitz, Kant, Haller? At the age of our graduates it is, besides, of the greatest importance that there be less reading and writing, less taxing of the memory, more exercise of the muscular system. Not learning, but health and character, should be the main objects in education and schooling, and therefore the education of the senses should be emphasized. Only a philologist will deny that grammar, with its many exceptions, is rather a heavy ballast for the memory than a proper means for the training of the logical faculty. The student involuntarily becomes accustomed to admit exceptions also in the case of other rules, ethical laws, the laws of nature, and in matters of his own experience. The elements of mechanics and chemistry—

these are objects of instruction which are incomparably more adapted to the young student for exercises in thinking, while having the additional advantage of appealing directly to the senses. The most delicate test of correct thinking is furnished by the experiment. The most natural way to make the intellect independent is through the occupation with the exact sciences, physics and chemistry, with elementary experiments forming a transition from play to the seriousness of reality; but *not through translations of the speeches, long since deprived of all vital interest*, of Greek or Roman *lawyers*, or of the *phraseology of dead languages* with their intricate syntax and superfluous particles.

"*I seize every opportunity to censure this unnatural condition*, and I blame it in this connection because it injures health. . . . I regret vividly that precisely in Germany, the home of physiology, the country in which it is honored the most, where the greatest means are placed at its disposal and laboratories resembling palaces are built for it, that here where the number of its learned adherents is the largest, the science is least known among the people at large. . . . Every educated person has been compelled in his youth to learn a lot of details —for instance, of Greek mythology, the history of the Church, of the Old and New Testaments, grammar, etc.—which in later years never again entered into the circle of his ideas, and only burdened his memory without the least advantage for his intellectual development, and his mental and moral education. As to the inner condition of his own body, the connection of the heart's beating with the breathing process, of the process of alimentation with the production of animal heat, and as to what is meant by muscles, nerves, ganglia, and how the gradual transformation of the tissues goes on in youth and old age—that is not taught, though there would be time enough for it, if less attention was paid to unnecessary matters."

If we contrast with these remarks of a scholar and scientist, who evidently knows whereof he speaks, the utterances of a lawyer like Lord Coleridge, or of a dealer in æsthetics like Mr. Matthew Arnold, we are struck with the absolute pertinence of the former, and the thin generality of the latter. "Sweetness and light" come with health, physical and mental; logical acumen comes from an accurate knowledge of things brought to the test of rigid experiment. Felicity of expression, or perfect harmony between the thought and its outward dress, is not limited to Greek and Latin writers, but is as general as literature itself. And if the progress from general knowledge of disconnected events to special knowledge of phenomena connected by invisible and yet omnipresent law everywhere marks the advance of human thought, why, then, should the intelligent study of the latter be a less efficient guide to "sweetness and light," or to the "highest education," than the study of literatures that dealt for the most part with problems which possess only slight interest, or none at all, for the best thinkers of to-day?

THE JURY SYSTEM.

By HENRY H. WILSON.

THIS is an age in which ancestral faiths, traditional customs, and primitive institutions alike, are receiving the attacks of iconoclasts. These attacks are always vigorous, usually just, frequently learned, but sometimes hasty and ill-considered. There was a time when institutions which had become quite useless were still continued and revered simply because they were ancient. In our day there is danger that institutions whose origin, growth, and practical utility are little understood may be swept away amid the general assault, merely because they bear the marks of age. Institutions are not the inventions of individuals, but are the outgrowth of the general sentiments and impulses of the time and place of their origin. Every institution, however absurd or worthless it may seem to us, must, at one time, have supplied the actual wants of a part of the human race. It is, therefore, but reasonable to presume that every institution which we have inherited contains some principle that may still be useful. Before assuming to pass judgment upon the merits or demerits of the jury as an element of our judicial system, it may, therefore, be well to inquire into its distinguishing features, and to ascertain, as far as may be, the origin of its several characteristics. Most prominent among the peculiar features of the modern jury are—1. That they are called from the vicinage, or from a limited territory, over which the court in which they sit has jurisdiction. 2. That they possess no previous knowledge of the merits of the case which they are impaneled to try. 3. That they consist of a definite number previously determined, usually twelve. 4. That unanimity or consent of all is necessary to render a verdict. 5. That they are chosen by lot from a certain number of qualified citizens previously selected. Of these in their order let us inquire the origin, growth, and present utility.

1. When, in its earliest stages, the jury was composed of the witnesses who knew more or less about the facts in dispute, it was natural and indeed necessary to call them from the vicinity where the transaction occurred. This reason becomes the more apparent, when it is remembered that the ordinary commercial transactions among our rude ancestors were accompanied with great ceremony and publicity. For example, if a man wished to go abroad to buy a horse, he must first announce his intention to do so to his neighbors, and upon his return he must give all the circumstances of the purchase, that the requisite number of witnesses, or men who knew the facts, could be had to form a jury, should his title ever be questioned. Should he fail to observe these precautions, he was presumed to have stolen the horse, or to have obtained it in some unlawful way.* While, in this com-

* Forsyth, "Trial by Jury," p. 71.

mercial age, when business extends over such wide territories, and when commercial transactions are usually evidenced more or less by written instruments, a debtor may be sued wherever he can be found, except in a few special cases, yet, on the other hand, crimes which, from the nature of the case, are evidenced usually and almost wholly by living witnesses, must still be tried in the vicinage or county where they were committed. While most civil actions may now be brought wherever the defendant may be found, yet the jury must be called from the vicinity of the forum in which they are tried. In the early history of the jury, vicinage meant simply the immediate neighborhood, while the same term is now used to denote the whole territory over which the court has jurisdiction. Calling the jury from the vicinage would seem to have the advantage of strengthening local self-government. Litigants usually have the assurance that their rights are to be determined, not by strangers who may be used to different customs and habits of life, but by their neighbors, upon whose rights they in turn may be called upon to adjudicate. And this feature of the jury has the further advantage that, while the jurors know nothing about the facts of the particular case, yet the parties have the benefit of whatever good repute they may sustain among their neighbors. So, while the reasons that gave rise to this restriction in calling a jury no longer exist, yet, when reasonable provisions are made for a change of venue in cases of violent popular feeling, there are some advantages derived from it, and there seems to be no good reason for a change.

2. We are next to consider the jury with reference to their previous knowledge of the facts in dispute. As before intimated, in the early stages of the system the jurors were called because they knew more or less about the facts in the case, and if, upon examination, it should be found that any one who was called was entirely ignorant of the facts to be tried, he was excluded, and another was called in his stead.* This process was continued until all those who could add nothing to the jury's knowledge of the case were excused, and the requisite number of those possessing such information were found. They were then sworn to render a true verdict, not upon the evidence produced in court, but upon the knowledge they themselves possessed, or upon the words of their fathers.† This explains the seeming anomaly of attaint for a false verdict. Should either party be dissatisfied with the verdict, he could demand a jury of double the usual number, to try the truthfulness of the former verdict.‡ This was simply trying the whole panel for perjury because they possessed the requisite knowledge, and had sworn that they would render a true verdict upon that knowledge.

It often happened that controversies would arise when twelve men

* Forsyth, "Trial by Jury," p. 105. † Stubbs, "Constitutional History," vol. i, p. 616.
‡ Forsyth, "Trial by Jury," p. 149.

could not be found who possessed the information necessary, and so, to those who knew the facts, were added others who joined in the verdict, relying on the knowledge and good faith of their fellow-jurors. From this the step was short and easily taken to that stage where witnesses not on the panel were called to give testimony concerning facts within their knowledge.* Here we find a jury, composed of informed and uninformed jurors, all joining in a common verdict.† Those who knew the facts in issue were, however, finally separated from those who did not,‡ and while the former gradually assumed the character of the modern witnesses who simply detail the facts under the sanction of an oath, the latter became the modern jury essentially as we now have it—that is, triers of facts upon evidence produced by others. So, while we challenge a juror because he knows too much about the facts to be tried, our ancestors objected to him because he did not know enough about them. Perhaps no other feature of the whole system of trial by jury has called forth so much adverse criticism as this. It is justly said that to rigorously enforce this rule in an age of newspapers and telegraph would exclude every intelligent citizen from juries called to try cases of any considerable notoriety. To meet the demands of our changing civilization, most if not all the States of the Union have, by statute, relaxed this once universal rule of the common law. An opinion founded on rumor or newspaper-reading will not now exclude a juror, and several of the States have gone to the doubtful length of authorizing the presiding judge to permit a juror to sit even though he have a decided opinion as to the merits of the case, provided he will swear that, notwithstanding such opinion, he believes he can render a fair and impartial verdict. It would be mere mockery to submit facts to a man who would not agree to determine them fairly and impartially; and if there be any place in which this rule is rigidly enforced it ought not to be urged against the whole system, when it can be remedied so easily without detracting at all from what is of real value in it. The reasonable application of the rule excluding from the jury those who have formed opinions upon *ex-parte* statements of the facts to be tried, certainly tends to insure a true verdict. No evidence should be laid before those who are to weigh it, except that which can be subjected to the crucial test of cross-examination. The frequent instances of a smooth, plausible, persuasive narrative in chief being totally contradicted by a shrewd cross-examination of the same witness shows how unreliable would be any decision made by either judge or jury upon statements heard out of court.

3. As to the origin of the number requisite to form a jury, it is impossible now to say anything definite. The number twelve of which

* Bigelow's "History of Procedure in England," p. 336.

† Forsyth, "Trial by Jury," p. 128.

‡ Stubbs, "Constitutional History," vol. i, p. 620.

the jury is composed in all probability came from the accustomed number of compurgators whom the plaintiff or defendant brought into court in early times, before the jury was known, to vouch for his veracity.* This being the quantum of proof required to render a party's testimony credible, it was natural that the same quantum of proof—that is, the verdict of twelve jurors possessing the necessary information—should be required to establish the existence or non-existence of the alleged facts. Thus determining the number of jurors necessary to render a verdict was simply fixing the amount of proof necessary to establish a fact if disputed. When jurors gradually ceased to be witnesses the number twelve was still retained, probably because there was no particular reason for changing it. Why there should have been twelve compurgators, why that was fixed upon as the quantum of proof necessary, it is impossible to say with any degree of certainty. Various reasons have been given by various antiquaries, none of which seem to have much more than speculation to support them.

Whatever may have been the origin of the number twelve, the reasons which gave rise to it have doubtless long ceased to exist, yet it may be difficult to point out why it should be changed. Should a majority be able to return a verdict, it would be an advantage to have the jury composed of some odd number, but so long as the law requiring unanimity remains, or should two thirds or three fourths be allowed to render a verdict, there seems no sufficient reason for changing the number. Should any change in this respect be made, it would seem expedient to make the number of jurors in some degree correspond to the importance of the issues to be tried.

4. The fourth characteristic feature of the jury which I shall consider is the requirement of unanimity in the verdict. This, like the number, is due to the fact that the ancient jury was composed of witnesses. Twelve lawful men must declare upon oath the existence of a fact before a verdict could be rendered. But, should they disagree, others were added until twelve out of the whole number were of one mind, which process was called afforcing the jury. This process resulted in allowing a bare majority to render a verdict whenever that majority consisted of twelve.† From this it is clear that it was the quantum of proof required, and not the probability of correctness arising from unanimity, that gave rise to the rule that twelve men must consent to the verdict. Since jurors are no longer witnesses, the rule has survived the circumstances that gave it birth.

Laws affecting millions of people are enacted by a mere majority and are equally binding on all; courts of last resort frequently decide by a bare majority as to the validity or proper application of those laws; and it is exceedingly difficult to understand why the unanimous verdict of twelve men is necessary to establish the existence of the facts to which such laws apply. When we remember how differently

* Forsyth, "Trial by Jury," p. 62. † Stubbs, "Constitutional History," vol. i, p. 616.

men are impressed by the occurrence of things that transpire before their eyes, how impossible it is for us always to agree upon the most ordinary affairs of life, when we remember that the jury is called only because two men, who are the litigants, can not agree, we will see the absurdity of putting twelve men into the jury-box to hear the most contradictory evidence of a particular fact, and then say that they must all agree! In many cases this agreement, when reached, is only apparent, and occasionally a false verdict is doubtless procured by the tenacity of some determined juryman. And still more frequently are juries discharged because they can not agree, and the parties and the public are subjected to the expense of another trial.

To give moderate room for honest difference of opinion, to disarm occasional prejudice and render corruption fruitless, I think in all civil causes three fourths of the jury ought to be able to return a verdict. It has been urged that the rule requiring unanimity is necessary to insure that every juror shall be heard and the grounds of his opinion considered. Indeed, this has been defended as the only redeeming feature of the whole system of trial by jury. If, after hearing all the evidence adduced, after counsel have exhausted their powers in presenting their respective sides of the case, after the presiding judge has pointed out the issues to be determined and laid down the rules of law applicable to them—I say, if, after all this, nine out of the twelve are agreed and are ready to render a verdict without the advice of the other three, it is very probable that the preponderance of evidence is on their side. In Nevada the three-fourths rule in civil cases has been in successful operation nearly twenty years, and bench, bar, and people alike, seem to be well satisfied with the result. Although this provision is in their State Constitution,* yet the Legislature by a two-thirds vote might introduce the rule of unanimity. That no attempt has been made to do so speaks volumes for the practical workings of the three-fourths rule. While I think that three fourths may safely be allowed to return a verdict in civil causes, I am inclined to believe that in criminal causes considerations of humanity demand, and the State can afford to grant every individual, such a strong presumption of innocence that only a unanimous verdict of twelve of his peers shall be able to overcome it. In civil causes, where a preponderance of evidence entitles either party to a verdict, it is illogical to require unanimity, but in criminal cases, where the defendant must be proved guilty beyond a reasonable doubt, it would be absurd to say that he may be convicted while a single voice from the jury-box is heard protesting that he is innocent. Should it be impossible for a jury in a criminal case to agree, they are discharged, and the defendant is put on trial again before another jury. So justice can be defeated only by the unanimous consent of twelve sworn men of the neighborhood, and, if justice may sometimes be delayed and extra expense incurred

* Constitution of Nevada, Article I, section 3.

by the disagreement of a jury, the State can afford to wait, and no expense should be balanced against the possibility of innocence. So I think that justice will be best insured by retaining the rule requiring unanimity in criminal cases, and in all civil causes permitting three fourths to render a verdict.

5. The fact that jurymen are chosen by lot has been the subject of no little ridicule, and yet I think no other method would, on the whole, prove as satisfactory. When juries were composed of those who knew the facts in dispute, the panel must have been drawn from a limited number, and often the whole number of witnesses were not sufficient to make a complete panel. At that time, knowledge of the matter in controversy determined who should be called to sit as jurors; but, when the jury became a tribunal for the trial of facts upon the testimony of others, the jurors were called from the whole number of citizens possessing the requisite qualifications. In most of the States of the Union the qualifications of a juror are the same as those of a voter, and the panel is chosen by lot. In this way the personal element is, if not eliminated, at least restrained, and the impersonal element—blind chance—that knows neither friend nor foe, decides who shall be the arbitrators. In popular election Justice may be defeated, but Fortune always gives her an even chance.

Having described some of the leading characteristics of the modern jury, I shall now consider some of its advantages—first, as a judicial tribunal; and, secondly, as a political institution. No one now questions the utility of the separation of the legislative or law-making power from the judicial or law-interpreting power. No less important is the separation of the power that decides upon the facts from the power that applies the law to the facts when so determined. The former is the province of the jury, and the latter that of the judge. It is the duty, and the whole duty, of the jury to determine whether certain facts do or do not exist. It is sometimes said that in criminal cases the jury are the judges of the law as well as the fact. This misapprehension arises, I think, from the nature and effect of the verdict rendered in such cases. On all issues joined in criminal cases the jury may bring in a general verdict of "guilty" or "not guilty," and, if the latter, the defendant can not be tried again, no matter how erroneous the verdict may be. And this, too, is the result, even though the verdict be contrary to the express instruction of the court. The jury are, however, bound to follow the instructions of the court in all matters of law, and if they do not they are false to their trust, however remediless the state may be. If, on the other hand, the jury return a special verdict, that is, that certain facts do exist, the court is bound either to act upon those facts as true, or set the verdict aside and submit the facts to another jury. Now, suppose the judge should usurp the power of the jury, and should, notwithstanding the verdict, declare the alleged facts untrue, or decide that the facts though true

do not constitute a crime, although by express statute they do, and suppose the judge so deciding, however erroneously, should discharge the defendant, would not the result be the same, and the state equally remediless? To this it will hardly be answered that judges can always be depended upon to do their duty, while jurors can not. The truth is, that the sole duty of the jury is to find the facts, and that of the judge to apply the law, and when either does more, except in those cases where the judge tries both, it is a usurpation of power.

Bearing in mind the fact that the only work of the jury is to determine the truth or falsity of certain alleged facts, let us inquire whether or not and how well it is adapted to this purpose. It is well known that technical training in any branch of learning has a peculiar influence on the mind. The mind by such training develops certain idiosyncrasies, and nothing is more common than to see an eminent specialist whose judgment is quite untrustworthy out of his specialty. A mind so trained usually adopts certain more or less artificial tests of truth, to which every proposition is submitted with a predetermination as to the relative weight of certain classes of evidence. Nothing is more boundless than the variety of facts that may be submitted for judicial determination, and these facts do not usually belong to any specialty, but arise out of the ordinary transactions of all men. No trade or profession can claim a monopoly of facts, and I am of the opinion that twelve men, coming to the work unbiased and untrammeled by any technical rules or artificial tests, are more likely to arrive at the truth in the ordinary affairs of life than any one, or indeed any number of specialists.

Perhaps the most frequent error alleged in appeals to the superior courts is that the verdict of the jury is against the weight of evidence, which is the nature of an appeal from the verdict of the jury on the facts, and yet it is safe to say that not one case in fifty is reversed on that ground. And, for every case reversed because the jury were wrong, more than a score are reversed for some error committed by the presiding judge in matters of law. I am aware that it is often said that only those who have the bad side of cases want to try them to a jury. This statement has little or no foundation in fact. Recently one of the foremost jurists of this country, who certainly is not overmuch attached to the jury system, said: "I am also forced to admit, however, that even in civil cases my experience as a judge has been much more favorable to jury trials than it was as a practitioner. And I am bound to say that an intelligent and unprejudiced jury, when such can be obtained, who are instructed in the law with such clearness, precision, and brevity as will present their duty in bold relief, are rarely mistaken in regard to the facts which they are called upon to find."* I think experience has shown what reason would

* Judge Miller's address before the New York Bar Association, "Albany Law Journal," vol. xviii, p. 409.

suggest, that the jury, with the modifications I have pointed out, is well adapted for its special work—the finding of facts.

But even stronger are the reasons for retaining the jury as a political institution. Some one has tersely said that it is not so necessary that the people get justice as that they should think they do. While this is, perhaps, putting it a little too strongly, yet there is much truth in it. Judges are usually chosen from a rank far above the mass of litigants, and the latter doubtless often feel that they are appealing for justice to one who has but little in common with the class to which they belong. And at this time, when there is a strong tendency to lengthen the tenure of judicial offices, it would be dangerous to cut off the popular branch of our judicature. The question that most threatens this country at present is the question of capital and labor. The tyranny that menaces us is not the tyranny of kings, but that of corporate capital. Whether the bench is really corrupted by the vast moneyed interests of the country is not material to the issue, if there is a deep-rooted suspicion of it in the minds of the people. Most men would feel safer, in a contest with one of these modern leviathans, to submit the facts in dispute to twelve men called from the vicinage, but what twelve no one could point out until the litigants had made the last challenge and the jury is in the custody of a sworn officer and beyond the reach of corrupting influences. Juries are doubtless sometimes corrupt, and sometimes go wrong by mistake, but the verdict of a jury, however erroneous, affects only one case, and neither establishes a bad precedent nor materially lessens our confidence in the system. The verdict deciding only the facts of the particular case has no influence upon the rights of any but the parties to that suit, and it is altogether improbable that the same twelve men will ever be called upon to sit together to try another case. So, however erroneous may be the verdict, and although every one may concede that it is wrong, no serious consequences follow, and the litigants in the next case proceed with the usual confidence in the justice of their fellow-men. It is only those who have a bad cause, or have lost confidence in mankind, that fear the jury. But how is it with the judges? Instead of their power ending with a single case, in the Federal courts and in seven States of the Union they hold their offices during life, and in the others for a term ranging from six to twenty-one years; and our present cumbrous method of impeachment, which can be effectual for nothing less than a "high crime or misdemeanor," affords but slight protection against ignorance, tyranny, or even corruption on the bench. If through ignorance or prejudice a judge has arrived at a wrong conclusion in one case, and from that conclusion there is no appeal, how can he be trusted in the next. And, still more, if he has yielded to the corrupting influences of power, or, what is practically the same thing, if the people believe he has so yielded, in one case, who but the powerful can trust him afterward? Ignorance

or corruption in a jury may affect a particular case, but ignorance or corruption of a judge affects the whole system upon which depend the rights of all. If a corrupt jury taints the waters for a moment, to become pure again the next, a corrupt judge poisons at its head the fountain from which all must drink. I am inclined to think that the corrupting influences of corporations upon our courts is greatly exaggerated, but it would be idle to underrate the strength of public opinion on this subject. When so many suspect the purity of the bench, we should consider well before we eliminate the popular element from our courts of justice. Let us do nothing to exclude in fact or alienate in feeling the people from one of our most important institutions lest the evil spirit should whisper in the ear of poverty the all-too-powerful argument of Romeo:

> "Art thou so bare, and full of wretchedness,
> And fear'st to die? famine is in thy cheeks,
> Need and oppression starveth in thy eyes,
> Contempt and beggary hang upon thy back,
> The world is not thy friend, nor the world's law;
> The world affords no law to make thee rich;
> Then be not poor, but break it and take this."

What do the opponents of the jury offer in its stead? The only substitute that has yet been proposed is an increase of judges and trial to the court in all cases. We have already seen that one of the most useful features of the system of trial by jury is the separation of the power that tries the facts from that which decides the law. A question of fact is tried upon evidence, in the weighing and considering of which the mind should be trammeled by no artificial tests or technical rules. On the other hand, to determine questions of law requires long experience and accurate knowledge of rules and principles evolved from the common experience of mankind. The judge must be learned in the common law scattered through thousands of volumes of reported cases, as well as thoroughly acquainted with the statutory and constitutional law of the land. A finding of fact in one case can not, from the nature of the circumstances, be any aid in determining another set of facts upon different evidence in another case, and hence a finding of fact, or a verdict of a jury, can have no authority as a precedent. On the other hand, a determination of a principle of law is final not only in that particular case, but in all similar cases in that jurisdiction—thus a court of last resort, in deciding a single case, may settle a principle of law upon which scores of other cases depend. Now, it is this separation of the trial of the law and the facts—functions essentially different in their nature and requiring entirely different kinds of training and preparation—that has enabled our courts to build up, develop, and unify our system of jurisprudence. This division of labor, which has had much to do in producing the certainty, completeness, and symmetry of our law, would be wholly lost by the

proposed change. It is suggested that, instead of a jury of twelve untrained men, three or five judges experienced in the law should determine both the law and the fact, and that such decision be final. This would certainly have the virtue of producing speedy justice, if justice at all. But what would be the result? Let us suppose a case. The Legislature passes a law which the judicial tribunal of one county holds to be unconstitutional, while that of another county declares it constitutional, and in two other counties it is construed to mean two quite different things, and so on through fifty counties, each of which has an independent, distinct, and final judicature. We see at a glance that there must be one supreme judicature whose jurisdiction is conterminous with that of the Legislature, whose will it interprets. The confusion now existing between the thirty-eight States in this regard is the source of much regret, and might have been fatal to the existence of the Union had it not been for the Federal Supreme Court, whose silent but constant influence gradually overcame the violence of contending factions. Then, by whatever tribunal cases are first tried, we must always have one Supreme or Appellate Court, and it is fair to presume that about as many cases would find their way into the higher courts, if first tried to the court, as if tried by a jury. And the proposed system would have the further disadvantage that, the higher a case were carried through the successive tribunals, the less would be the probability of a correct determination of the facts. While the appellate tribunals are usually best qualified to settle a question of law, they are, from their technical training and tendency to generalize, least qualified to determine a question of fact. Nor can we reasonably expect a reduction in expense by employing high-salaried specialists to do that which the ordinary laymen can do much better.

It is suggested, however, that justice would more certainly be meted out to litigants if the whole subject of controversy were in the hands of a few experienced men. Might not the same be said of the legislative branch of our Government? A score of well-trained lawyers could doubtless enact a more consistent and probably a better code of laws than any of our heterogeneous Legislatures, yet this would scarcely induce the people to make the change. Indeed, the strongest, cheapest, and best government is an absolute despotism in the hands of a strong, wise, good man. But the character of an institution ought to be estimated by its effects on the people, and that is on the whole the best which produces the best results. It is not only what people are called upon to actually do, but also the possibilities that lie before them, that affects their character. The occasional deposit of a ballot is not of itself much of a public education, but the possibilities and responsibilities that the elective franchise brings with it can scarcely be overestimated in their influence on the character of a people. Much the same is the influence of the popular branch of our system of judicature. While the direct influence of sitting occasion-

ally as a juror ought not to be underestimated, yet I think still greater good comes from the increased responsibility of the people at large. There will be fewer criminals when every citizen feels that he is in some sense a conservator of the peace. The direct educating influence of trial by jury has often been remarked by those who have studied the influences that mold the character of nations. Bentham, who certainly will not be charged with venerating anything because it is old, in speaking of the jury as a public educator says: "Every judicatory, of which a jury forms a part, is a school of justice; without the name, it is so in effect. In it the part of master is performed by the judge; the part of scholars by the jurymen; and what takes place, takes place in a company more or less numerous of spectators. The representation there given is given by a variety of actors, appearing in so many different parts."* I believe that the people will not willingly give up an institution to which they owe so much of their self-reliance and ability to govern themselves until stronger reasons than any yet suggested are presented.

THE CHEMISTRY OF COOKERY.

By W. MATTIEU WILLIAMS.

XXIV.

SINCE the publication of my last paper, I have learned the proper name of the Swiss compound there described as *fondevin*, according to my recollection of its pronunciation in Switzerland. In an old edition of Mrs. Rundell's "Domestic Cookery," it is described as *fondu*. A similar dish is described in that useful book "Cre-Fydd's Family Fare," under the name of *cheese soufflé* or *fondu*. I had looked for it in more pretentious works, especially in the most pretentious and the most disappointing one I have yet been tempted to purchase, viz., the twenty-seventh edition of Francatelli's "Modern Cook," a work which I can not recommend to anybody who has less than £20,000 a year and a corresponding luxury of liver.

Amid all the culinary monstrosities of these "high-class" manuals, I fail to find anything concerning the cookery of cheese that is worth the attention of my readers. Francatelli has, under the name of "Eggs à la Swisse," a sort of *fondu*, but decidedly inferior to the common *fondu* of the humble Swiss osteria, as he lays the eggs upon slices of cheese, and prescribes especially that the yolks shall not be broken; omits the milk, but substitutes (for high-class extravagance' sake, I suppose) "a gill of double cream," to be poured over the top. Thus

* Bentham's works, vol. ii, p. 125.

the cheese is not intermingled with the egg, lest it should spoil the appearance of the unbroken yolks, its casein is made leathery instead of being dissolved, and the substitution of sixpenny worth of double cream for a halfpenny worth of milk supplies the high-class victim with fivepence halfpenny worth of biliary derangement.

In Gouffe's "Royal Cookery-Book" (the *Household Edition* of which contains a great deal that is really useful to an English housewife) I find a better recipe under the name of *cheese soufflés*. He says: "Put two and one fourth ounces of flour in a stewpan, with one and a half pint of milk; season with salt and pepper; stew over the fire till boiling, and, should there be any lumps, strain the *soufflé* paste through a tammy-cloth; add seven ounces of grated Parmesan cheese, and seven yolks of eggs; whip the whites till they are firm, and add them to the mixture; fill some paper cases with it, and bake in the oven for fifteen minutes."

Cre-Fydd says: "Grate six ounces of rich cheese (Parmesan is the best); put it into an enameled saucepan, with a teaspoonful of flour of mustard, a saltspoonful of white pepper, a grain of cayenne, the sixth part of a nutmeg, grated, two ounces of butter, two tablespoonfuls of baked flour, and a gill of new milk; stir it over a slow fire till it becomes like smooth, thick cream (but it must not boil); add the well-beaten yolks of six eggs, beat for ten minutes, then add the whites of the eggs beaten to a stiff froth; put the mixture into a tin or a cardboard mold, and bake in a quick oven for twenty minutes. Serve immediately."

Here is a true cookery of cheese by solution, and the result is an excellent dish. But there is some unnecesary complication and kitchen pedantry involved. The following is my own simplified recipe:

Take one fourth of a pound of grated cheese; add it to a gill of milk in which is dissolved as much powdered *bicarbonate of potash* as will stand upon a threepenny-piece; mustard, pepper, etc., as prescribed above by Cre-Fydd.* Heat this carefully until the cheese is completely dissolved. Then beat up three eggs, yolk and whites together, and add them to this solution of cheese, stirring the whole. Now take a shallow metal or earthenware dish or tray that will bear heating; put a little butter on this, and heat the butter till it frizzles. Then pour the mixture into this, and bake or fry it until it is nearly solidified.

A cheaper dish may be made by increasing the proportion of cheese—say, six to eight ounces to three eggs, or only one egg to a quarter pound of cheese for a hard-working man with powerful digestion.

The chief difficulty in preparing this dish conveniently is that of

* Before the Adulteration Act was passed, mustard-flour was usually mixed with well-dried wheaten-flour, whereby the redundant oil was absorbed, and the mixture was a dry powder. Now it is different, being pure powdered mustard-seed, and usually rather damp. It not only lies closer, but is much stronger. Therefore, in following any recipe of old cookery-books, only about half the stated quantity should be used.

obtaining suitable vessels for the final frying or baking, as each portion should be poured into, and fried or baked in, a separate dish, so that each may, as in Switzerland, have his own *fondu* complete, and eat it from the dish as it comes from the fire. As demand creates supply, our ironmongers, etc., will soon learn to meet this demand if it arises. I am about writing to Messrs. Griffiths & Browett, of Birmingham, large manufacturers of what is technically called "hollow-ware"—i. e., vessels of all kinds knocked up from a single piece of metal without any soldering—and have little doubt that they will speedily produce suitable *fondu* dishes according to my specification, and supply them to the shopkeepers.

The bicarbonate of potash is an original novelty that will possibly alarm some of my non-chemical readers. I advocate its use for two reasons: First, it effects a better solution of the casein by neutralizing the free lactic acid that inevitably exists in milk supplied to towns, and any free acid that may remain in the cheese. At a farm-house where the milk is just drawn from the cow it is unnecessary for this purpose, as such new milk is itself slightly alkaline. My second reason is physiological, and of greater weight. Salts of potash are necessary constituents of human food. They exist in all kinds of wholesome vegetables and fruits, and in the juices of *fresh* meat, but *they are wanting in cheese*, having, on account of their great solubility, been left behind in the whey.

This absence of potash appears to me to be the one serious objection to the free use of cheese-diet. The Swiss peasant escapes the mischief by his abundant salads, which eaten raw contain all their potash salts, instead of leaving the greater part in the saucepan, as do cabbages, etc., when cooked in boiling water. In Norway, where salads are scarce, the bonder and his housemen have at times suffered greatly from scurvy, especially in the far north, and would be severely victimized but for special remedies that they use (the mottebeer, cranberry, etc., grown and preserved especially for the purpose. The Laplanders make a broth of scurvy-grass and similar herbs). Mr. Lang attributes their recent immunity from scurvy, which was once a sore plague among them, to the introduction of the potato.

Scurvy on board ship results from eating salt meat, the potash of which has escaped by exosmosis into the brine or pickle. The sailor now escapes it by drinking citrate of potash in the form of lime-juice, and by alternating salt-junk with rations of tinned meats.

I once lived for six days on bread and cheese only, tasting no other food. I had, in company with C. M. Clayton, son of the Senator of Delaware (who negotiated the Clayton-Bulwer Treaty), taken a passage from Malta to Athens in a little schooner, and expecting a three days' journey we took no other rations than a lump of Cheshire cheese and a supply of bread. Bad weather doubled the expected length of our journey.

We were both young, and, proud of our hardihood in bearing privations, were stanch disciples of Diogenes; but on the last day we succumbed, and bartered the remainder of our bread and cheese for some of the boiled horse-beans and cabbage-broth of the forecastle. The cheese, highly relished at first, had become positively nauseous, and our craving for the vegetable broth was absurd, considering the full view we had of its constituents, and of the dirtiness of its cooks.

I attribute this to the lack of potash salts in the cheese and bread. It was similar to the craving for common salt by cattle that lack necessary chlorides in their food. I am satisfied that cheese can never take the place in an economic dietary otherwise justified by its nutritious composition, unless this deficiency of potash is somehow supplied. My device of using it with milk as a solvent supplies it in a simple and natural manner.

XXV.

My first acquaintance with the rational cookery of cheese was in the autumn of 1842, when I dined with the monks of St. Bernard. Being the only guest, I was the first to be supplied with soup, and then came a dish of grated cheese. Being young and bashful, I was ashamed to display my ignorance by asking what I was to do with the cheese, but made a bold dash, nevertheless, and sprinkled some of it into my soup. I then learned that my guess was quite correct; the prior and the monks did the same.

On walking on to Italy I learned that there such use of cheese is universal. Minestra without Parmesan would there be regarded as we in England should regard muffins and crumpets without butter. During the forty years that have elapsed since my first sojourn in Italy my sympathies are continually lacerated when I contemplate the melancholy spectacle of human beings eating thin soup without any grated cheese.

Not only in soups, but in many other dishes, it is similarly used. As an example, I may name "Risotto à la Milanese," a delicious, wholesome, and economical dish—a sort of stew composed of rice and the giblets of fowls, usually charged about twopence to threepence per portion at Italian restaurants. This is always served with grated Parmesan. The same with the many varieties of paste, of which macaroni and vermicelli are the best known in this country.

In all these the cheese is sprinkled over, and then stirred into the soup, etc., while it is hot. The cheese being finely divided is fused at once, and, being fused in liquid, is thus delicately cooked. This is quite different from the "macaroni cheese" commonly prepared in England by depositing macaroni in a pie-dish, and then covering it with a stratum of grated cheese, and placing this in an oven or before a fire until the cheese is desiccated, browned, and converted into a horny, caseous form of carbon that would induce chronic dyspepsia in the stomach of a wild-boar if he fed upon it for a week.

In all preparations of Italian pastes, risottos, purées, etc., the cheese is intimately mixed throughout, and softened and diffused thereby in the manner above described.

The Italians themselves imagine that only their own Parmesan cheese is fit for this purpose, and have infected many Englishmen with the same idea. Thus it happens that fancy prices are paid in this country for that particular cheese, which is of the same class as the cheese known in our midland counties as "skim dick," and sold there at about fourpence per pound, or given by the farmers to their laborers. It is cheese "that has sent its butter to market," being made from the skim-milk which remains in the dairy after the pigs have been fully supplied.

I have used this kind of cheese as a substitute for Parmesan, and I find it quite satisfactory, though it has not exactly the same fine flavor as the best qualities of Parmesan, but is equal to that commonly used by the Italian millions. The only fault of our ordinary whole-milk English and American cheeses is that they are too rich, and can not be so finely grated on account of their more unctuous structure, due to the cream they contain.

I note that in the recipes of high-class cookery-books, where Parmesan is prescribed, cream is commonly added. Sensible English cooks, who use Cheshire, Cheddar, or good American cheese, are practically including the Parmesan and the cream in natural combination. By allowing these cheeses to dry, or by setting aside the outer part of the cheese for the purpose, the difficulty of grating is overcome.

I have now to communicate another result of my cheese-cooking researches, viz., a new dish—*cheese-porridge*—or, I may say, a new class of dishes—cheese-porridges. They are not intended for epicures, not for swine who only live to eat, but for men and women who eat in order to live and work. These combinations of cheese are more especially fitted for those whose work is muscular, and who work in the open air. Sedentary brain-workers like myself should use them carefully, lest they suffer from over-nutrition, which is but a few degrees worse than partial starvation.

Typical cheese-porridge is ordinary oatmeal-porridge made in the usual manner, but to which grated cheese is added, either while in the cookery-pot or after it is taken out, and yet as hot as possible. It should be sprinkled gradually and well stirred in.

Another kind of cheese-porridge or cheese-pudding is made by adding cheese to *baked* potatoes—the potatoes to be taken out of their skins and well mashed while the grated cheese is sprinkled and intermingled. A little milk may or may not be added, according to taste and convenience. This is better suited for those whose occupations are sedentary, potatoes being less nutritious and more easily digested than oatmeal. They are chiefly composed of starch, which is a heat-

giver or fattener, while the cheese is highly nitrogenous, and supplies the elements in which the potato is deficient, the two together forming a fair approach to the theoretically demanded balance of constituents.

I say *baked* potatoes rather than boiled, and perhaps should explain my reasons, though in doing so I anticipate what I intended to say when on the subject of vegetable food.

Raw potatoes contain potash salts which are easily soluble in water. I find that when the potato is boiled some of the potash comes out into the water, and thus the vegetable is robbed of a very valuable constituent. The baked potato contains all its original saline constituents which, as I have already stated, are specially demanded as an addition to cheese-food.

Hasty-pudding made, as usual, of wheat-flour, may be converted from an insipid to a savory and highly nutritious porridge by the addition of cheese in like manner.

The same with boiled rice, whether whole or ground, also sago, tapioca, and other forms of edible starch. Supposing whole rice is used, and I think this the best, the cheese may be sprinkled among the grains of rice and well stirred or mashed up with them. The addition of a little brown gravy to this gives us an Italian risotto.

Peas-pudding is not improved by cheese. The chemistry of this will come out when I explain the composition of peas, beans, etc.

I might enumerate other methods of cooking cheese by thus adding it in a finely divided state to other kinds of food, but if I were to express my own convictions on the subject I should stir up prejudice by naming some mixtures which some people would denounce. As an example I may refer to a dish which I invented more than twenty years ago—viz., fish and cheese pudding, made by taking the remains from a dish of boiled codfish, haddock, or other *white* fish, mashing it with bread-crumbs, grated cheese, and ketchup, then warming in an oven and serving after the usual manner of scalloped fish. Any remains of oyster-sauce may be advantageously included.

I find this delicious, but others may not. I frequently add grated cheese to boiled fish as ordinarily served, and have lately made a fish sauce by dissolving grated cheese in milk with the aid of a little bicarbonate of potash. I suggest these cheese mixtures to others with some misgiving as regards palatability, after learning the revelations of Darwin on the persistence of heredity. It is quite possible that, being a compound of the Swiss Mattieu with the Welsh Williams, cheese on both sides, I may inherit an abnormal fondness for this staple food of the mountaineers.

Be this as it may, so far as the mere palate is concerned, I have full confidence in the chemistry of all my advocacy of cheese and its cookery. Rendered digestible by simple and suitable cookery, and added, with a little potash salt, to farinaceous food of all kinds, it

affords exactly what is required to supply a theoretically complete and a most economical dietary, without the aid of any other kind of animal food. The potash salts may be advantageously supplied by a liberal second course of fruit or salad.—*Knowledge.*

SCIENCE AND SAFETY AT SEA.

By RICHARD A. PROCTOR.

IN the autumn of 1879 the steamship Arizona, five thousand tons, at that time the swiftest ocean-going steamship in existence, was urging her way, at the rate of some fifteen knots an hour, on the homeward course from New York, whence she had sailed but a day or two before. It was night, and there was a light haze, but of danger from collision with a passing ship there was little or none. The captain and crew knew of no special reason for watchfulness, and the passengers were altogether free from anxiety. Indeed, it so chanced that at a time when, in reality, the most imminent danger threatened every soul on board, many of the saloon-passengers were engaged in purchasing at auction the numbers for the next day's run—runs below three hundred and fifty knots being sold at a very low rate indeed. Suddenly a crash was heard, the ship's swift progress was stopped, and a few minutes later every one knew that the Arizona had run dead upon an enormous iceberg, the spires and pinnacles of which could be seen hanging almost over the ship, and gleaming threateningly in the rays of her mast-head light. But the risk that threatened her living freight was not that of being crushed by falling ice. The bows of the Arizona were seen to be slowly sinking, and presently there was a well-marked lurch to starboard. The fore compartment and a smaller side compartment were filling. It was an anxious time for all on board. Many an eye was turned toward the boats, and the more experienced thought of the weary miles which separated them from the nearest land, and of the poor chance that a passing steamer might pick up the Arizona's boats at sea. Fortunately, the builders of the Arizona had done their work faithfully and well. Like another ship of the same line which had been exposed to the same risk, save that her speed was less, and therefore the danger of the shock diminished, the Arizona, though crippled, was not sunk. She bore up for St. John's, and her passengers were taken on later by another steamer.

The danger which nearly caused the loss of the Arizona—collision with an iceberg—is one to which steamships, and especially swift steamships, are exposed in exceptional degree. Like this danger, also, it is one which renders the duty of careful watching, especially in the night and in times of haze or fog, a most anxious and important care.

But, unlike the risk from collision with another ship, the risk from collision with icebergs can not be diminished by any system of side-lights or head-lights or stern-lights, except in just such degree (unfortunately slight) as a powerful light at the foremast-head, aided by strong side-lights or bow-lights, may serve to render the gleam of the treacherous ice discernible somewhat farther ahead. But to a steamship running at the rate of fourteen or fifteen knots an hour, even in the clearest weather, at night, the distance athwart which a low-lying iceberg can be seen, even by the best eyes, is but short. She runs over it before there is time for the watch to make their warning heard, and for the engineers to stop and reverse their engines.

But science, besides extending our senses, provides us with senses other than those we possess naturally. The photographic eyes of science see in the thousandth part of a second what our eyes, because in so short a time they can receive no distinct impression at all, are unable to see. They may, on the other hand, rest on some faintly luminous object for hours, seeing more and more each moment, where ours would see no more—perhaps even less—after the first minute than they had seen in the first second. The spectroscopic eyes of science can analyze for us the substance of self-luminous vapors or of vapors absorbing light, or of liquids, etc., where the natural eyes have no such power of analysis. The sense of feeling, or rather the sense for heat, which Reid originally and properly distinguished as a sixth sense (not to be confounded, as our modern classification of the senses incorrectly confounds it, with the sense of touch), is one which is very limited in its natural range. But science can give us eyes for heat as keen and as widely ranging as the eyes which she gives us for light. It was no idle dream of Edison's, but a thought which one day will be fraught with useful results, that science may hereafter recognize a star by its heat, which the most powerful telescope yet made fails to show by its light. Since that was said, the younger Draper (whose loss followed so quickly and so sadly for science on that of his lamented father) has produced photographic plates showing stars which can not be seen through the telescope by which those photographs were taken. As yet the delicate heat-measurers devised by science have not been applied to astronomical research with any important results. But Edison's and Langley's heat-measurers have been used even in this way, and the very failure which attended the employment of Edison's heat-measurer (the tasimeter, or, literally, the strain-measurer, described shortly before in the "Times") during the eclipse of 1878 shows how delicate is the heat-estimating sense of science. When the light of the corona—which has no heat that the thermometer, or even that far more delicate heat-measurer, the thermopile, will recognize—fell on the face of the tasimeter, the index which Edison supposed likely to move just perceptibly actually flew beyond the index-plate. Thus, though the heat of the corona could not be measured, the extreme

delicacy of the tasimeter was demonstrated unmistakably. Langley's heat-measurer is scarcely less sensitive, and probably more manageable. But in point of fact each instrument is more sensitive than the heat-sense of science is required to be, to do the work I have now to indicate; and an instrument can readily be constructed which shall be, in the right degree, less sensitive than they are, though it might be difficult at present to invent any that should be more senstive.

The sense of sight is not the only sense affected as an iceberg is approached. There is a sensible lowering of temperature. But to the natural heat-sense this cooling is not so obvious or so readily and quickly appreciated that it could be trusted instead of the outlook of the watch. The heat-sense of science, however, is so much keener that it could indicate the presence of an iceberg at a distance far beyond that over which the keenest eye could detect an iceberg at night; perhaps even an isolated iceberg could be detected when far beyond the range of ordinary eye-sight in the day-time. Not only so, but an instrument like the thermopile, or the more delicate heat-measurers of Edison and Langley, can readily be made to give automatic notice of its sensations (so to speak). As those who have heard Professor Tyndall's lectures any time during the last twenty years know, the index of a scientific heat-measurer moves freely in response either to gain or loss of heat, or, as we should ordinarily say, in response either to heat or cold. An index which thus moves can be made, as by closing or breaking electrical contact, or in other ways, to give very effective indication of the neighborhood of danger. It would be easy to devise half a dozen ways in which a heat-indicator (which is of necessity a cold-indicator), suitably placed in the bows of a ship, could note, as it were, the presence of an iceberg fully a quarter of a mile away, and speak of its sensations much more loudly and effectively than the watch can proclaim the sight of an iceberg when much nearer at hand. The movement of the index could set a fog-horn lustily announcing the approach of danger; could illuminate the ship, if need be, by setting at work the forces necessary for instantaneous electric lighting; could signal the engineers to stop and reverse the engines, or even stop and reverse the engines automatically. Whether so much would be necessary—whether those among lost Atlantic steamships which have been destroyed, as many have been, by striking upon icebergs, could only have been saved by such rapid automatic measures as these—may or may not be the case; but that the use of the infinitely keen perception which the sense-organs of science possess for heat and cold would be a feasible way of obtaining much earlier and much more effective notice of danger from icebergs than the best watch can give, no one who knows the powers of science in this direction can doubt.—*London Times.*

SKETCH OF ORMSBY MACKNIGHT MITCHEL.

WITH the year 1842 practically commences the history of astronomical science in America. In that year, ORMSBY MACKNIGHT MITCHEL, a young graduate of West Point, and Professor of Mathematics at Cincinnati, having met with success in lecturing before his classes, was invited to give a course in the college hall. So successful was he in this course, and so great was the interest that he awakened in the subject, that he resolved to turn it to account, and enlist his hearers in the work of building an observatory. As the wealthier cities of the Eastern States had not yet moved in the direction, his plan was regarded by many as impracticable, but, after vigorous personal application, he succeeded in obtaining sufficient subscriptions to warrant a commencement of the work. The enterprise took shape by the organization of the Cincinnati Astronomical Society. Professor Mitchel had no observatory to model from, no practical knowledge of astronomy, and no instrument-makers from whom to purchase instruments or object-glasses. All this must be taught in older countries, and he resolved to go to Europe to this end. In order to husband his resources, he proceeded first to Washington, in the hope that he might be given some mission from the State Department, the remuneration for which would pay his expenses. Mr. Webster, then Secretary of State, informed him that his request was impossible, and nearly everybody, including President Tyler, was inclined to sneer at him as an impractical enthusiast. There was one notable exception —John Quincy Adams spoke words of kindness and encouragement. His application failed, and he proceeded on his journey, crossing the ocean in a sailing-vessel. Upon arriving in England, he looked for an object-glass, but found none worthy of his attention. From England he proceeded to Paris, and called upon M. Arago at the observatory there, who received him kindly; but, not finding what he desired in France, he proceeded to Germany, where he found a fine glass in the Frauenhofer works at Munich, which he purchased. Returning to England, he entered as a student in the Royal Observatory at Greenwich, and for some months devoted himself to the study of practical astronomy. Upon his return to America, he applied himself vigorously to the work of getting his observatory building ready for the reception of the equatorial telescope that he had ordered in Munich. He desired to secure the services of Mr. John Quincy Adams to deliver the oration at the laying of the corner-stone, and went to Niagara, where he learned Mr. Adams was sojourning at the time, to induce him to go to Cincinnati for that purpose. Notwithstanding the opposition of Mr. Adams's family, on account of his advanced age and infirmity, and the difficulties attending so long a journey in a stage-coach, so great was the ex-President's interest in the matter, and

so certain did he feel it to be his duty, that he consented. On November 9, 1842, he delivered the address.

The time required to mount the glass, financial depression, and various discouragements prevented the completion of the building and the arrival of the teleseope till the spring of 1845, when Professor Mitchel commenced his duties. He occupied himself in the ordinary routine of astronomical work. He paid considerable attention to perfecting instruments for attaining greater delicacy of observation. He claimed to be the first (though he found a rival to dispute this honor with him) to make a clock record its beats, thus obtaining a graphical and more minute measurement of time.

The pioneer of American observatories was not destined to be long-lived. Before many years rolled round, the smoke from the growing city at the base of the hill on which it stood rendered observations impossible. Its immediate successor, containing its instruments, is located some five or six miles from the original site, and other observatories, built afterward, occupy many a hill-top throughout America.

At the time the observatory was finished, an accident occurred which at first seemed very unfortunate for Professor Mitchel, but which in the end served to call out the full extent of his practical powers. The building of the college, from which he drew his only means of support, took fire and burned to the ground. The observatory was without endowment, and he had engaged to be its director for ten years without compensation, relying for support on his college professorship. He determined to enter the field as a professional lecturer on astronomy. With characteristic boldness he proceeded to Boston, believing that if he could succeed in that critical city, where the arts and sciences had been so thoroughly cultivated, and which numbered among its own citizens so many men of high scientific attainment, he could succeed elsewhere. He met with perfect success, and thus commenced that series of brilliant efforts in every city in the United States which lasted for fifteen years.

He published, in 1848, "Planetary and Stellar Worlds"; in 1860, "Popular Astronomy"; he also published, from 1846 to 1848, the "Sidereal Messenger," a periodical; and after his death a fragment, entitled "Astronomy of the Bible," was given to the public. These works, though the progress of science and of thought has left them now far behind, are still read by some who can discern in them the ardent poetic nature of their author. But his great work in science was in exciting an interest, wherever he appeared in person, to talk of the wonders of the heavens. He never attempted to *amuse* an audience, and never dropped below the dignity of the sublime subject of which he spoke. When flights of eloquence came to him, they seemed to meet him from among the lofty realms to which he ascended. Thither he carried his hearers, not by diagrams, not by

actual pictorial representations, but by language alone. He possessed the power of magnetism to a remarkable degree. He could at once gain the sympathy of his audience, and always held it till he had ceased to speak. To him, far more than to any other man, is due the interest that grew up in astronomical science in America between the years 1842 and 1860, for there was scarcely a town or city in the United States in which he did not speak during that period.

In 1859 he delivered a course of lectures in the Academy of Music in New York for the benefit of an observatory that it was proposed to erect in Central Park. The last lecture of this course was the last he ever delivered. It was a fitting close to a brilliant work. The Academy was crowded almost to the ceiling. On the platform were seated many of the most prominent men in New York. As he led his audience out into space, to planet and sun and system, it became powerfully moved. When he closed, the ordinary methods of applause seemed inadequate. His hearers rose from their seats and cheered—an act not uncommon at meetings of a political nature, but probably without precedent at an astronomical lecture.

In 1860 Professor Mitchel was called to the directorship of the Dudley Observatory at Albany, the building of which he had himself designed.

At the opening of the late civil war, Professor Mitchel felt called upon to turn the military education he had received to the account of the Government that had given it. He was appointed a brigadier-general of volunteers. At the time of his appointment, Cincinnati—his former home—was threatened by the Confederates, and he was sent to defend it. After fortifying the city, he desired to occupy East Tennessee. By order of the Secretary of War, he organized a force for the purpose; but it was necessary to move through a department commanded by another general. That general would not consent, and the expedition had to be abandoned.

In April, 1862, he found himself in command of a division of General Buell's army (detached from the main column, then proceeding on the route to Corinth), and directed to observe the country south of him. Without orders, he proceeded by forced marches to Huntsville, Alabama, surprised and captured that part of the railroad and territory lying between Stevenson and Decatur, with seventeen locomotives and eighty cars, and held the territory he had been ordered to observe. For this service President Lincoln promoted him to be major-general. He asked for troops with which to march through Georgia, but Mr. Lincoln replied that all available forces had been given to General McClellan and General Halleck. He then asked to be transferred to a more active field, but Mr. Lincoln directed him to remain for future operations in the territory where his "military genius had effected so much." Upon General Buell's arrival with the rest of the Army of the Ohio at Huntsville, in July, 1862, General Mitchel

urged an immediate advance into East Tennessee. General Buell delayed, and General Mitchel asked to be relieved. It was not, however, till the President determined to use him in a special service that he ordered him to report at Washington.

Mr. Lincoln proposed to send an army down the Mississippi under his command. He selected the force and wrote the order; but just at that time concluded to appoint General Halleck his military adviser. When General Halleck arrived at Washington he declined to appoint General Mitchel to this command. For two months he was unemployed, and in September, 1862, was sent, by General Halleck's order, to the then quiescent Department of the South, in South Carolina. Here he died of yellow fever on the 30th of October, 1862. His term of military service was fourteen months. During this time he found but one opportunity to act upon his own uncontrolled judgment.

Professor Mitchel was born in Union County, Kentucky, August 28, 1810. At twelve years of age, having acquired a tolerably fair knowledge of Latin and Greek and the elements of mathematics, he became a clerk in Miami, Ohio, but afterward removed to Lebanon, in the same State where he had been educated. He entered the Military Academy at West Point in June, 1825, having himself earned the money with which he was enabled to reach the school. After being graduated in 1829, he became acting Assistant Professor of Mathematics in the Academy, and served in that capacity for two years. He then removed to Cincinnati, where he practiced law till 1834, when he became Professor of Mathematics, Philosophy, and Astronomy, in Cincinnati College, a position in which he remained for ten years, or till the college-building was burned.

Of the more important features of his work at the observatory, "Nature" says, in an article on "Observatories in the United States" (July 9, 1874): "At the request of Professor Bache, the telegraph company connected the observatory with their stations for determining longitude, Cincinnati being then a central point in such work. The astronomer royal, under whose instruction Mitchel had passed three months in 1842, urged, in an encouraging letter, that 'the first application of his meridional instruments should be for the exact determination of his geographical latitude and longitude, and that his observing energies should be given to the large equatorial.' With this advice, he directed his attention largely to the remeasurement of Struve's double stars south of the equator.

"Airy and Lamont had invited him to make minute observations of the satellites of Saturn, since in the latitude of Cincinnati the planet is observed at a more favorable altitude than at Pulkova, twenty degrees farther north. To these, and chiefly 'to the physical association of the double, triple, and multiple stars,' he gave his close attention. He made interesting discoveries in the course of this re-

view. 'Stars which Struve had marked as oblong were divided and measured; others marked double were found to be triple.' He proposed a new method for observing, and new machinery for recording north polar distances or declinations. Professor Peirce reported favorably on this method at the meeting of the American Association in 1851, and Professor Bache, as Superintendent of the Coast Survey, indorsed their approval in his report for that year, presenting also a full account of work done by the new method in observations made by the enthusiastic astronomer and his patient wife, who assisted him through all. It was claimed that the results rivaled the best work done at Pulkova. Mitchel was the first 'to prepare a circuit interrupter with an eight-day clock, and to use it to graduate the running fillet of paper'; and to invent and use the revolving-disk chronograph for recording the dates of star-signals. Professors Bache and Walker had declined to adopt the first of these improvements in astronomical appliances, through an apprehension of injury to the astronomical clock. Mitchel's work proved the apprehension to be groundless. His revolving disk is an invaluable invention.

"To the perfection of such methods and instruments, together with the routine work of observation, he gave all the energies not of necessity employed in outside labors devolving on him for his support. Unhappily these, at an early date, became almost absorbing. For the Astronomical Society, having secured their observatory and their director, had failed to secure a basis for its support."

Of his lectures, "Nature" remarks that he stirred up an enthusiasm by them "which quickened the movements resulting in the establishment of some of the first observatories of this day in the United States."

General Mitchel always acted with the incentive of genius rather than talent, if such a distinction exists. Hence his proposals were often regarded as impracticable. Their practicability depended upon his energy, resource, and magnetism. Without these, they would have been mere visionary schemes.

His simplicity and purity of character, his earnest patriotism and military foresight, are all minutely recorded in his correspondence. It is expected that the record will some day pass—one of its many chapters—into the voluminous history of the rebellion.

CORRESPONDENCE.

MOSQUITOES AND MALARIA.

Messrs. Editors:

"WHO shall decide when doctors disagree?" Not long since was put forth the theory that the "bite" of the mosquito is a genuine antidote for malaria, and one of the arguments used to sustain the assertion was that Nature provides remedies alongside all forms of disease, and that, wherever malaria abounded, mosquitoes did much more abound, and were busily engaged, to the best of their ability, in injecting a tonic under the skin of poor ague-stricken humanity, which would effectually cure the disease if the humane work of the winged surgeons was not interfered with; and now comes Professor King, in the September number of your journal, with the startling claim that the mosquito is the very *cause* of malarial diseases!—and the problem, Shall we encourage or kill the insect? is still unsolved.

Having had some experience with these much-denounced insects in the woods and by the inland lakes in the northern part of the Lower Peninsula of Michigan, and on and beside the lagoons of Southern Florida and even in the hotel sleeping-rooms in many parts of the land, I feel compelled to differ with Professor King in some of his alleged "facts," and I fear some of my statements will at least throw a doubt over the supposed "established facts" of the professor.

The professor argues that a locality abounds in mosquitoes, and that malaria is found to prevail in the same locality, and therefore it is quite probable that the malarial diseases there are produced by the mosquitoes.

Suppose we assume that it is quite as probable that the condition of heat, moisture, soil, and vegetation, merely makes the locality a spot favorable to the generation of both mosquitoes and malaria, without any connecting relation one with the other. Suppose, again, we find localities where the mosquito, during a part of the year, is, by the power of numbers and fierceness of attack, almost king of the woods, and yet there is no malaria to be feared or found.

I have been in several localities on Indian River and Mosquito Lagoon, on the south-east coast of Florida, where I would not like to have been on the outside of my netting, under the little shelter-cabin of our sail-boat, but I have never seen more numerous and, in localities, more voracious mosquitoes than in our northern forests in Michigan. The efforts on the part of these insects to produce malarial disease, in some form, if this is their mission, were never more persistent than there. I have from the best authority the fact that it is no very uncommon thing for hardy woodsmen, in the spring months, to be driven from their work in the forest by the mosquitoes and black flies; but the general rule is, in the milder attacks, for the choppers to become so accustomed to the mosquitoes, day and night, as to pay little attention to them, they "let 'em bite," only disturbing them when, by an unusual attack, they overstep the reasonable demands for blood. Many of these men have come under my personal observation during a residence of from two to six weeks each year for seven years at our summer resort on Grand Lake, three miles back from Lake Huron. As I knew them to be working day after day in the low cedar lands, often in wet swamps, and drinking the swamp water where they could find a pool under some old moss-bed, and often sleeping in rude log or board shanties in the same locality, I have often asked them if they did not get the ague, or "chills" and fever. The answer was always, "Never." I have seen many little children, from the babe up, with naked legs, feet, arms, and no head-covering but the hair, absolutely covered more with mosquito-bites than garments, all through the season, but I have never known a case of malarial disease in any form among them. In view of these observations, I must conclude the case is hardly made out that mosquitoes produce malarial diseases, although in many localities the two are co-existent.

The professor says it is a fact of common observation that mosquitoes are more numerous in the late summer months. I am not sure of other localities, but in Upper Michigan, at our resort, and all through Northern Michigan, the fact is exactly the reverse. We usually require nettings during July. About the 1st of August the mosquitoes begin to disappear, and we can sleep without nettings; but, during May, June, and July, if they created malarial diseases, there would be lively shakes among the settlers, where malarial diseases are now unknown, or of extremely rare occurrence.

I do not know but the sea-coast mosquito is a more wicked fellow, but our North Michigan mosquitoes, I believe, are engaged in better work than creating malaria. In fact, I am not sure but that the "bites" of mosquitoes, in the cases of our northern cedar-cutters, and their freedom from disease in great exposure furnish the "antidote" for the malarial tendency of the

swamp air and swamp water, and furnish an argument for the antidote theory rather than otherwise.

We can hardly accord to Professor King the soundness of his argument, that because miasma and mosquitoes prevail at night, therefore the mosquito is the author of miasma. Does the mosquito produce the miasma in the air, or create the disease by his "bite"? Suppose we say bats fly only at night, and dew falls only at night, therefore the bats create the dew?

The night air may be congenial to both malaria and mosquitoes, as it may be to both bats and dew, without any further relationship. If Professor King will spend a week or a month in May or June in our northern cedar-lands, I will warrant him more mosquito-bites to the square inch of exposed person than there are pounds of atmospheric pressure on the same surface, and I will also guarantee him safety from all malarial disease. F. R. STEBBINS.

ADRIAN, MICHIGAN, *October* 8, 1883.

A REPLY TO EDITORIAL STATEMENTS.

Messrs. Editors:

IN your editorial comments on the classical question, you refer to Germany as favorable to the old education on account of royalty and the Bismarckian *régime;* you also quote from "Science" a condemnation of German scientific writers. Allow me, in the briefest manner, to set you right on these two points. Whatever you may think of Bismarck, you should, in the present discussion, at least state that Bismarck does not favor Greek, but thinks it is only studied for a make-believe of mental superiority; also that he has emphatically stated that the state must take its civil officers wherever they can be found, efficiency being the only test, not the approval, etc., of the university; and, thirdly, you should bear in mind that Bismarck is no favorite with the Berlin University, the latter being much more of your opinion as to the "*régime*" now existing in Prussia than of an opinion favorable to Bismarck.

While I share your views as to the aristocratic tendencies that take shelter under the Latin-Greek education, I yet believe that respect for royalty in Germany is fostered mainly by the common school, while the universities are decidedly democratic in their influence.

As regards the lack of clearness and order formerly so common in German scientific writers, I beg to call your attention to the many excellent scientific writers that Germany can *now* point to, when a comparison with other countries is instituted. I believe a somewhat careful investigation would startle those who accept the common dogma that German scientific writers are obscure and deficient in order. Schleiden, the botanist, Carl Vogt, Du Bois-Reymond, Virchow, Haeckel, are only a few of the best-known German scientists who excel in order and clearness, and in the graces of style. No modern literature has scientific works superior in order, clearness, and style, to those of George Forster and Jacob Moleschott, and yet the former excelled, and the latter still excels, in scientific work. In a country like Germany, where so many write, bad writing is apt to be more readily noticed. As for the absence of important generalizations by German scientists, I think this subject should be treated separately. Kepler's grand generalizations were written in Latin; Leibnitz published many of his in French; there are other authors distinguished for important generalizations, who, if they can not compare with Darwin, yet occupy a high rank—for instance, Dr. J. R. Mayer, who first formulated the great law of heat-equivalents, and hence of the conservation of force.

I should be glad to find that your *sense of justice* is strong enough to make the corrections your statements and the extract require. C. A. E.

IOWA CITY, *December* 26, 1883.

Our sense of justice is perhaps not very strong, but it is put to no strain by publishing the foregoing. We referred to the "Bismarckian *régime*" only as a name for the present phase of the administration of the German Government, and our argument could not depend upon any man's personal views, because it rested upon the broad declaration of the university authorities that the ascendency of the classics must be maintained for church and state reasons. It is interesting to know that Bismarck regards Greek as a humbug, but he would probably be the last man to deny that shams may have their political uses.

The quotation from "Science" was made, not because we approved or considered pertinent all that it said, but because it testified decisively to the neglected condition of the native speech on the part of a people long given over to the worship of classical ideals. Our correspondent recognizes "the lack of clearness and order formerly so common in German scientific writers." He, however, enumerates several recent writers that are not open to this charge. But are not those exceptions to a general practice? and would it not have been somewhat more to the point to inform us whether or not these writers were assiduous cultivators of the classics?—ED.

EDITOR'S TABLE.

COLLEGIATE INFLUENCE UPON THE LOWER EDUCATION.

THERE is one aspect of the broad classical controversy of momentous importance, but which has been much neglected in the general discussion of the subject. We refer to the relation of our collegiate system to the system of education in the schools of lower grade. It is only by scrutinizing this relation that we can really appreciate the extent of the practical antagonism between the classical and the scientific systems of study, and recognize how completely the colleges are all on one side in this issue.

We are abundantly assured that, whatever may have been the case in the past, there is now no ground of complaint that the dead languages usurp too much attention, while the sciences are correspondingly neglected. The curriculums are appealed to to show that classical studies are no longer in the way of science, which is every year receiving increasing attention in these institutions. New laboratories, observatories, and museums, are pointed at to show the augmenting facilities of scientific study, and we are told that, by the growing optional system, the student is more and more allowed a choice of subjects when he enters college, which enables him, if he likes, to give a larger portion if not his entire time to science.

But all this does not mean so much as it appears to mean. We are not for a moment to regard the influence of the colleges as limited to the students who come under their direct control. They exert a varied and powerful influence upon the secondary schools, upon the methods of early teaching, and upon both the youthful and adult mind of the community at large, which is overwhelmingly in behalf of the classics, and solid against science. They not only determine the prior studies of the great numbers who enter college, but they set the standards of education for multitudes who never pass to the higher institutions. They sustain and they enforce an ideal of culture which shapes the policy and fixes the character of the whole system of instruction that deals with the common education of the people. The alleged liberality implied by the optional system is misleading, if it is taken to imply any real liberty of the student to choose his studies untrammeled by college requirements, for not the slightest option is allowed as between the dead languages and the sciences in that prior period when the youthful mind receives its bent in the lower or preparatory schools. The relaxation of classical demands after admission to college, so far from indicating a diminished exaction of dead-language studies, is accompanied by an increasing stringency of requirement in these subjects before college is entered. With increasing option in college the standard of preparation is raised, which means that more Greek and Latin is forced upon the preparatory schools. The point of strain is shifted, but this is done in such a way as greatly to aggravate the evils of classical study. The worst influence of the colleges upon general education, as we have often maintained, is their reactive effect upon the preparatory schools, and the whole secondary system of instruction to which the youthful mind of the country is subjected. By their demands upon these institutions, the colleges lend their influence to maintain throughout the community an ideal of culture that is predominantly and in effect exclusively classical. Modern studies have no status, no recognition in the preparatory stage

of those who propose to obtain a so-called liberal education. The alleged concessions to the spirit of progress are therefore illusive. The concessions made to science after entrance into college are not allowed in the period of early study when they would be far more valuable. Nothing substantial is conceded to science when our colleges keep their classical standards of admission so high that all the time of pupils is consumed in Latin and Greek preparation. No concession is made to science when proficiency in scientific studies gained at school is not allowed to count in entering college. No such concession is made by a collegiate system that does not provide by imperative requirement for some thorough grounding in scientific branches in the preliminary schools, and which does not allow solid proficiency of scientific attainment to open the way to the highest college honors.

But the radical antagonism of our colleges to educational progress through their reactive influence upon the lower school system is only to be fully appreciated when we understand in what that progress consists. In its philosophy, traditional education is very much where it was a hundred years ago, but it is undeniable that many important principles have been reached which are of the greatest moment as guides to better educational practice. A century of science is not to go for nothing in the treatment of this subject. There are relations among the great divisions of modern knowledge which are fundamental in laying down courses of study. There is an order in the development of the human faculties which is fundamental to the art of rational and successful teaching. There is an ideal of the highest purpose in cultivating the intellect—the investigation of the truth of nature by various processes—which has been developed by the advance of science. Systematic and comprehensive efforts have been made to reduce this new ideal to practice in the lower sphere of education. Efforts have been made to teach first the things which belong first in the course of mental unfolding, to bring the young mind into closer relations with the facts of experience, to cultivate more thoroughly the all-important habit of observation, and to provide for the training of the active and inventive powers by simplified experiment and various manipulations, and finally to make the operations of study exercises in investigation and in original and independent thought upon subjects within the common sphere of intelligence, and adapted to educate the judgment. It is no longer a question that these supreme objects can be secured to very considerable degree by proper methods of dealing with the minds of youth, and great progress has been made in recent times in working out the practical methods by which they are attained. But the whole movement belongs to the lower schools, and the whole influence of our college system upon those schools is not to help but to hinder it. In illustration and confirmation of this view, we quote some remarks made by Dr. Barnard, President of Columbia College, at the dinner given in New York to Professor Tyndall in 1873:

> I say, then, that our long-established and time-honored system of liberal education—and when I speak of the system, I mean the whole system, embracing not only the colleges, but the tributary schools of lower grade as well—does not tend to form original investigators of Nature's truths; and the reason that it does not is, that it inverts the natural order of proceeding in the business of mental culture, and fails to stimulate in season the powers of observation. And when I say this, I must not be charged with treason to my craft—at least not with treason spoken for the first time here, for I have uttered the same sentiment more than once before in the solemn assemblies of the craft itself.
>
> I suppose, Mr. President, at a very early period of your life you may have devoted, like so many other juvenile citizens, a portion of your otherwise unemployed time to experiments in horticulture. In planting legumi-

nous seeds you could not have failed to observe that the young plants come up with their cotyledons on their heads. If, in pondering this phenomenon, you arrived at the same conclusion that I did, you must have believed that Nature had made a mistake, and so have pulled up your plants and replanted them upside-down. Men and women are but children of a larger growth. They see the tender intellect shooting up in like manner, with the perceptive faculties all alive at top; and they, too, seem to think that Nature has made a mistake, and so they treat the mind as the child treats his bean-plant, and turn it upside-down to make it grow better. They bury the promising young buds deep in a musty mold formed of the decay of centuries, under the delusion that out of such *débris* they may gather some wholesome nourishment; when we know all that they want is the light and warmth of the sun to stimulate them, and the free air of heaven in which to unfold themselves. What heartless cruelty pursues the little child-martyr every day and all the day long, at home or at school alike; in this place bidden to mind his book and not to look out of the window—in that, told to hold his tongue and to remember that children must not ask questions! . . .

Among the great promoters of scientific progress, how large is the number who may, in strict propriety, be said to have educated themselves. Take, for illustration, such familiar names as those of William Herschel, and Franklin, and Rumford, and Rittenhouse, and Davy, and Faraday, and Henry. Is it not evident that Nature herself, to those who will follow her teachings, is a better guide to the study of her own phenomena than all the training of our schools? And is not this because Nature invariably begins with the training of the observing faculties? Is it not because the ample page which she spreads out before the learner is written all over, not with words, but with substantial realities? Is it not because her lessons reach beyond the simple understanding and impress the immediate intuition? That what she furnishes is something better than barren information passively received—it is positive knowledge actively gathered?

If, then, in the future we would fit man properly to cultivate Nature, and not leave scientific research, as, to a great extent, we have done heretofore, to the hazard of chance, we must cultivate her own processes. Our earliest teachings must be things, and not words. The objects first presented to the tender mind must be such as address the senses, and such as it can grasp. Store it first abundantly with the material of thought, and the process of thinking will be spontaneous and easy.

This is not to depreciate the value of other subjects, or of other modes of culture. It is only to refer them to their proper place. Grammar, philology, logic, human history, *belles-lettres*, philosophy—all these things will be seized with avidity and pursued with pleasure by a mind judiciously prepared to receive them. On this point we shall do well to learn, and believe we are beginning to learn something, from contemporary peoples upon the Continent of Europe.

Object-teaching is beginning to be introduced, if only sparingly, into our primary schools. It should be so introduced universally. And in all our schools, but especially in those in which the foundation is laid of what is called a liberal education, the knowledge of visible things should be made to precede the study of the artificial structure of language and the intricacies of grammatical rules and forms.

The knowledge of visible things—I repeat these words that I may emphasize them, and, when I repeat them, observe that I mean *knowledge* of visible things, and not information about them—knowledge acquired by the learner's own conscious efforts, not crammed into his mind in set forms of words out of books.

But how do our colleges stand as a body in regard to these explicit requirements of educational progress? Their whole power is exerted to defeat them. They force Latin and Greek upon all the preparatory schools; they make grammar and verbal studies, which should belong later in the course, imperative in early years; they supplement the classics by mathematics, and give the go-by to all the natural sciences. There is not the slightest provision in the studies introductory to college for any cultivation of the mind by immediate intercourse with the facts of nature. We have before us "A Comparative View of the Requisitions for Admission to Representative American Colleges, correct to 1880–'81," printed in the prospectus of the Berkeley School of New York city. Latin, Greek, and mathematics are of course the staple studies, and the amount of requirement in these sub-

jects is given in detail. Under the head of miscellaneous are included such further subjects as the several institutions hold important for admission to college. The common element here is English grammar, but neither Yale, Princeton, Columbia, Brown, Dartmouth, Williams, Amherst, Trinity, Michigan University, Vassar, Smith, nor Johns Hopkins, requires a shred of scientific preparation of any kind, unless school-geography is allowed to pass for science. Harvard requires some acquaintance with physics and *either* chemistry or botany, and Cornell includes physiology among the preparatory studies. By all these leading and influential collegiate institutions, which arrogate to themselves the prerogative of conferring a "liberal education," the study of Nature is absolutely left out in the early period of study, and nothing worthy of the name of science is recognized or required, when the foundations of intellectual character are being laid. There is one everlasting grind in grammar—Greek grammar, Latin grammar, English grammar—until the mental habits are formed by verbal studies; and then when the student enters college he is offered some restricted liberty of taking up scientific subjects.

Undoubtedly, the great issue of science against the classics is made up and to be met here. The continuance of the system of discrimination against modern knowledge, and in favor of dead languages, is not to be tolerated. The college premiums on old studies condemned by the common sense of mankind, and doubly damaging in early youth, must be withdrawn. Those institutions can not too soon take measures to get out of the way of the improvement of the lower schools. It is becoming more and more obvious, as shown by the current discussion of the subject, that there is urgent necessity for a readjustment of the relations of the higher and lower systems of instruction, and in evidence of this we quote the following instructive passages from an excellent article by Mr. R. R. Bowker, in the "Princeton Review" for January, on "The College of To-day":

> This brings us face to face with the at present difficult problem of the relations of the college to the general education out of which its curriculum must proceed. It is noticeable that while there has been much activity in the improvement of the higher education, and much progress, following the suggestions of Froebel and Pestalozzi, in primary education, the immediate education remains much where it was, and blocks the road in the middle. Our common schools are still "grammar-schools," although, as has been noted, educators are in agreement that "grammar," as such, is the one thing that should not be taught until the very highest grades are reached. And the colleges can not do their proper work, nor can an approximately correct curriculum be put into practice, until many features of the middle schools are not only reformed but revolutionized. The scheme of the proper education, following the child from its first lessons, should be developed in view of two chief conditions: the order in which the natural development of the mind fits it for the reception of successive studies; and the practical fact that, since the number to be educated decreases each year beyond the early years, the essential subjects must be presented early in the course. Happily, these two conditions largely coincide. The present curriculum of the middle schools has developed from the practical recognition of this last condition, in ignorance of the first, but through much misconception as to which are essential subjects. It is, of course, important that every child should be taught to speak, to write, to read, to figure, correctly; but it is now known that the child learns correct speech, for instance, chiefly through its observing faculties, by imitation, and not through its reflective faculties, by study of grammar. The child develops through the what, the how, the why—first the fact, next its relations, lastly its causes; and yet the lower schools will be teaching the laws of grammar, and leaving the facts of nature, as the elements of botany, for which the child-mind is hungering and thirsting, to the advanced student. The college professor of the natural sciences, for instance, should find the foundations laid for him when the student enters college, whereas now he must begin at elementary

facts. A correct college curriculum is scarcely possible as middle education stands now. Recognizing, then, the fact that the order in which the mind can best learn is the order in which it can best be taught, it becomes of the utmost importance that the college, admitting the necessity of present compromise, should exert its full influence to reorganize the education below.

It thus appears that the antagonism of the classical institutions to the popular schools in their real purpose is of a very radical kind. Our colleges, by their history and traditions, are academic, scholastic, and literary institutions, designed at least theoretically to form a learned class; while on the other hand the great body of the subordinate schools is devoted to the general education of the people, which should be practical and useful, based upon common needs and a preparation for the working duties of life. The colleges by their policy are chiefly solicitous to make the lower schools tributary to their own prosperity; but they must take larger views of their own interests by ceasing their indirect resistance to the progress of education in the lower schools, and by efficiently helping it forward. In an enlarged view, as Mr. Bowker well remarks, "the colleges can not do their proper work, nor can an approximately correct curriculum be put into practice until many features of the middle schools are not only reformed but revolutionized." But this revolution of the middle schools is a revolution that must begin in the colleges themselves, by which their exclusive exaction of a classical preparation is abandoned, and the sciences are given an equal chance with the dead languages. The classical gentlemen may league together to resist this change, but it will be of little avail; sooner or later it is sure to come. We observe by the last report of the President and Treasurer of Harvard College, 1882–'83, that this question is under serious consideration by the authorities of that institution, and, if they shall see fit to take the step now so urgently demanded, other institutions will be certain to follow.

President Eliot says (page 16): "The College Faculty is the body in which almost all the considerable changes, made during the past sixteen years in the educational methods of Harvard College, and of the schools which regularly feed it, have been first studied in detail, and then wrought into practical shape; and it is at present engaged, not for the first time, in the discussion of the gravest question of university policy which has arisen, or is likely to arise, in this generation—namely, the extent to which option among the different subjects should be allowed in the examination for admission to college."

LITERARY NOTICES.

EXCURSIONS OF AN EVOLUTIONIST. By JOHN FISKE. Boston: Houghton, Mifflin & Co. Pp. 379. $2.

MR. FISKE has laid the reading public under many obligations by the reissue of these more recent papers, which embody his matured views on a wide and varied range of topics. Nothing need be said in commendation of the literary work of a writer who has been long recognized as unrivaled in the art of lucid, effective, and pleasing exposition. But we are not to forget that these accomplishments have been put to the noblest service, and make him the most admirable interpreter of a new epoch in the advance of human thought. Mr. Fiske's writings belong eminently to a transition era in philosophic and scientific progress, and are in a high sense authoritative representations of it. And this is much to say of any one man's relation to a mental movement more comprehensive in its bearings upon widely received opinion than any that has ever before taken place.

There can be no doubt that Mr. Fiske's "Cosmic Philosophy" must rank first among the few masterpieces of expository statement contributed by this age on the subject of evolution. It is *the* book for the people upon this subject. It is not only an eminently instructive but a most charming work.

The author handles the great problems involved with originality and power, and at the same time with a clearness, a felicity of illustration, and a fascination of style, that give the work an unequaled claim upon popular regard. And we do not for a moment mean by this that the treatise is lowered in quality to adapt it to uncultivated minds. Its peculiar excellence is, that while it treats of abstract and difficult questions, in such a way that the uninitiated may pursue the discussions with satisfaction, the most adept minds will also be profoundly interested. We have seen a school-boy absorbed in the work; and Mr. Charles Darwin, after having gone slowly and carefully through it, wrote to the author, "I never in my life read so lucid an expositor—and therefore thinker—as you are"; and he adds, "It pleased me to find that here and there I had arrived from my own crude thoughts at some of the same conclusions with you, though I could seldom or never have given my reasons for such conclusions." The testimony of Mr. Darwin is corroborated by that of many others, the effect of which is to accord to Mr. Fiske an eminent and enviable place among those who have command of the questions that are now occupying the most earnest attention of the thinking world.

These considerations are important in their bearing upon our estimate of the present volume. The most fertile conception ever launched into the intellectual sphere is that of universal evolution. As deep as the forces of nature, it is as broad as the phenomena of nature. It is a new view of the movement of things, a new interpretation of their most comprehensive relations. There is hardly any great subject that escapes its influence. It has necessitated a recasting of the sciences, and a thorough-going reorganization of knowledge. So productive and all-influential an idea can be but partially dealt with in the most systematic and elaborate treatises; outstanding problems still remain to be solved and new applications of the doctrine worked out. Mr. Fiske has pursued the subject, after the publication of his elaborate book several years ago, in various aspects and in new directions, developing many points that were there but briefly touched upon. The volume before us consists mainly of these supplemental excursions in various directions, but all animated and characterized by the fundamental doctrine to which his first work was devoted. We recommend it to all students of the course of modern thought and the critical questions of the time, and can give our readers no better idea of the variety and instructiveness of its contents than by quoting the titles of the subjects treated. These are:

1. Europe before the Arrival of Man. 2. The Arrival of Man in Europe. 3. Our Aryan Forefathers. 4. What we learn from Old Aryan Words. 5. Was there a Primitive Mother-Tongue? 6. Sociology and Hero-Worship. 7. Heroes of Industry. 8. The Causes of Persecution. 9. The Origins of Protestantism. 10. The True Lesson of Protestantism. 11. Evolution and Religion. 12. The Meaning of Infancy. 13. A Universe of Mind Stuff. 14. In Memoriam. Charles Darwin.

INTERNATIONAL SCIENTIFIC SERIES. VOL. XLVII.

FALLACIES. A VIEW OF LOGIC FROM THE PRACTICAL SIDE. By ALFRED SIDGWICK, Berkeley Fellow of Owens College, Manchester. D. Appleton & Co. Pp. 375. Price, $1.75.

IT is curious that the subject, which is at the same time the most important, the most practical, and which involves questions of the deepest intellectual interest—that is, the science and art of correct reasoning—should somehow have come to be regarded as the dullest and heaviest of all subjects. No doubt this repulsiveness of logic is very much due to that ancient pedantic formality which was imparted to it in scholastic times and has continued ever since, and also to the fact that its practical objects have been forgotten in the development of its processes. University drill in logic has become itself the end without much reference to its reduction to utilitarian practice. Whatever may be the cause of the unattractiveness of logic, much of it must certainly be due to prejudices arising from its imperfect presentation. In his book on "Fallacies," Professor Sidgwick has made a very successful attempt to rescue the subject from its repellent forms, and to deal with it in a way that shall be interesting to the general

reader. The book is, therefore, written as much as possible from an unprofessional point of view, and in a way to require no previous technical training. Although any treatment of fallacies must, to a great extent, deal with methods of proof, and must, therefore, demand a certain amount of general logical theory, yet by trying to keep chiefly in view the practical and applicable side of the science of logic, and subordinating all else to this, Professor Sidgwick claims to have been able to neglect the discussion of much debatable matter, and to avoid definite adherence to a school. Mill and Bain are chiefly followed, but the author has attempted to utilize their most important results without being compelled to accept the whole of their philosophy. The following passages from Professor Sidgwick's introductory chapter may serve to illustrate the point of view from which he regards his subject, and also his fresh and unconventional manner of writing upon it:

Logic holds what may well be called an uncomfortable position among the sciences. According to some authorities, it can not be properly said that a body of accepted logical doctrines exists; according to others, the facts and laws that form such doctrine are so completely undeniable, that to state them is hardly to convey new or important information. Hence, if a writer on the science tries to avoid truism, and so to give practical importance to his statements, there is danger both of real but crude innovation, and also of over-simple belief in the value of merely verbal alterations. Moreover, at its best, logic has many persistent enemies, and by no means all of them are in the wrong; so that those who view the science as the thief or burglar views the law, find themselves apparently supported and kept in countenance by others who really have the right to view it as perhaps the artist views the rules that hamper genius. Through its deep connection with common sense, logic is often a source of exasperation to philosophy proper; while common sense, on the other hand, is apt to dread or dislike it as unpractical or over-fond of casuistical refinements. Failing thus to win a steady footing, it turns, sometimes, to physical science for a field of operations; but physical science has its proper share of boldness, and often leaves the cautious reasoner behind. As for art—which finds even common sense too rigid—here logic is liable to meet with opposition at every grade; from the righteous impatience of poetic souls that are genuinely under grace, down to the incoherent anger of mere boastful vagueness, or to the outcry of the sentimental idler.

In the midst of these perplexities, it is difficult to choose a quite satisfactory course. Some excuses may, however, be offered for the line that has here been taken; and, first, I would plead, as against the charge of irregularity or presumption, the fact that I have wished to keep a single purpose in view, avoiding all questions that fail to bear directly upon it. Usually in works on logic, the object has been to say something valuable upon all the questions traditionally treated as within the field of the science, and, in attempting this, the single, practical purpose is apt to become obscured. It is only in consequence of my avoidance of side-issues that any appearance of novelty in the treatment has followed. Moreover, it is not teaching, but suggestion that is chiefly here intended. It is always allowable to write rather in the co-operative spirit than the didactic, and this has certainly been my aim throughout. And the same apology may apply to the charge of forcing verbal changes upon the reader; the novelties of statement are here put forward merely as possible aids in keeping our single purpose clear, and, in fact, I found them almost unavoidable.

As regards physical science, it must be confessed that logic merely follows after it, systematizing methods already adopted there, and found to lead to good results. And I hold that to combat fallacy is the *raison d'être* of logic; and that science, though not infallible, is more free from discoverable fallacies than any other field of thought. Again, while experimental methods may no doubt be capable of much improvement, it seems a tenable view that the duty should be left to a special and very advanced department of inquiry. There might, perhaps, be formulated a system of advice for discovery in general—rules and hints important even to the leading men of science. But, in the mean time, logic (as usually understood) can hardly help containing a good deal of elementary matter, and is compelled to take for granted in the learner a power of making very elementary mistakes. It seems that the best scientific discovery must always be in advance of inductive logic, in much the same way as the best employment of language runs in advance of grammar. Still, there may be some use in trying to direct and help those who are not already scientific, or only in the earlier stages of the pursuit; nor need the name [of logic compel logicians to claim a dignity beyond their power. One can not fulfill successfully the duties of lord chancellor and justice of the peace at once.

A Natural History Reader. For School and Home. Compiled and arranged by James Johonnot, author of "Principles and Practice of Teaching," etc. New York: Pp. 414. D. Appleton & Co. Price, $1.25.

The work of the compiler of this volume has been executed with intelligence, taste, and good practical judgment, and he has made of it a most interesting book of natural history for general reading. It is an excellent sign of the healthy growth of an interest in science when works of this kind are called for and introduced into schools. The literature of science must

undoubtedly precede its actual and more thorough cultivation, and a great point will have been gained when this literature secures a prominent and established place in the schools. It is a concession to the rights of knowledge. Hitherto we have stopped with rhetoric, careless of the contents of thought, and in subserviency to the dogma that style and expression are everything. Such works as this are tributes to a sounder view, and evidences of advancement in the right direction. On this subject Professor Johonnot well remarks:

"Under the later system, the truth is recognized that the object of all school exercises is to promote mental growth, to which end ideas and thoughts are indispensable. Words, like bank-notes, are regarded not for their intrinsic but for their representative value. In so far as they clearly reveal the gold of thought, they may be taken for genuine coin, but, failing in this, they are worthless counterfeits. The kinds of ideas and thoughts are also a matter of serious moment. In each stage of the mind's growth, those only should be used that will command the attention by the interest excited, that will stimulate the reflective activities of the mind, and that will incite to further observation and investigation.

"With these objects kept clearly in view, reading and the general acquisition of language become secondary and not primary processes. They are incident to the general objects of instruction. Reading-matter is selected upon the same principles as studies—that which will interest, stimulate, and incite. At every stage of growth it is such as will best serve the present purposes of the mind, and, at the same time, promote the next step in advance. The pupil reads because he is anxious to know. His progress is rapid, because he is interested. His manner of reading is correct, because he understands the thought, and thought controls the expression."

We must add that the "Natural History Reader" is an attractive and a handsome book. It is beautifully illustrated, poems are interspersed with the prose chapters, and it is elegantly printed. Its selections are from the most recent writings of naturalists, and the information they convey will be found fresh and up to the times.

LECTURES ON PAINTING. Delivered to the Students of the Royal Academy. By EDWARD ARMITAGE, R. A. New York: G. P. Putnam's Sons. Pp. 337. $1.75.

PROFESSOR ARMITAGE has given in this book a selection of twelve from the lectures delivered by him during the term of his professorship in the Royal Academy, between 1876 and 1882. He has published them under the impression that they might be interesting to other students than those of the Royal Academy, "and possibly even to those who do not intend to follow art as a profession, but who would be glad to have a little daylight thrown on a subject which, though much written and lectured about of late years, does not seem to have been often treated in a simple, practical manner." The subjects of the lectures are, "Ancient Costume," "Byzantine and Romanesque Art," "The Painters of the Eighteenth Century," "David and his School," "The Modern Schools of Europe," "Drawing," "Color," "Decorative Painting," "Finish," "The Choice of a Subject," "The Composition of Decorative and Historical Pictures," and the "Composition of Incident Pictures."

ARCHIVOS DO MUSEU NACIONAL DO RIO DE JANEIRO (Archives of the National Museum of Rio de Janeiro). Dr. LADISLAO NETTO, General Director. Vol. III, 1878, pp. 194, with Six Plates; Vol. IV, 1879, pp. 154, with Six Plates; Vol. V, 1880, pp. 470. Rio de Janeiro: Typographia Economica.

THE "Archives" are a quarterly publication of papers on scientific subjects that properly come under the purview of the Museum. The present volumes include the publications for the second half of 1878, and for 1879 and 1880. In the third volume are included papers on the venom of the rattlesnake, by Dr. Lacerda; on the geology of the diamond-bearing region of the Province of Paraná, by Orville A. Derby; observations on geological features in the Bay of Todos os Santos, by Mr. Derby and Richard Rathbun; and other papers of a more special character. The fourth volume contains a number of anthropological and linguistic studies on the natives of the country, and papers on subjects of entomology and geology. The fifth volume is given to the "Flora Fluminensis," a Flora, in

Latin, of the Province of Rio, composed in the last century by Fr. José Marianno da Conceição Velloso, and first published in 1825.

TERTIARY HISTORY OF THE GRAND CAÑON DISTRICT. By CLARENCE E. DUTTON. Washington: Government Printing-Office. Pp. 264, with Forty-two Plates, accompanied by an Atlas of Twenty-three Plates.

THE Grand Cañon of the Colorado is characterized by some of the most wonderful rock-formations and the most gorgeous yet desolate scenery to be found anywhere on the earth. Captain Dutton has made the study and the description of it a labor of love, and the present volume, with its striking illustrations and the accompanying atlas with its grand panoramas and bird's-eye views, many of them, as well as the illustrations in the volume, colored according to nature, constitute one of the most welcome contributions to our literature and knowledge which the United States Geological Survey has made. Mr. Dutton's account of the geology, formation, characteristics, and scenery of the cañon takes notice of every aspect in which the wonder is likely to be viewed. Among the details of the account, to which we would invite attention, are the carved niches or panels in the red-wall limestone, and the exquisite tracery of the rounded and inward curves and projected cusps of the walls, which are represented in plates 41 and 42 of the volume.

ELECTRICITY IN THEORY AND PRACTICE; OR, THE ELEMENTS OF ELECTRICAL ENGINEERING. By Lieutenant BRADLEY A. FISKE, U. S. N. New York: D. Van Nostrand. 1883. Pp. 265. Price, $2.50.

WHOEVER will carefully read Lieutenant Fiske's lucid exposition will have no excuse for persistence in the hazy notions concerning the relation of electrical effects, and the power requisite to produce them, not uncommon among even the intelligent and educated public. Very few persons, perhaps, are in the position, in regard to their knowledge of electricity, of the man who wanted to know why they should have a steam-engine and a dynamo-machine to make an incandescent lamp go, or of that English couple who purchased a Swan lamp and spent much time trying to light it with a match; but the ignorance which abounds on the subject is still very considerable. With the great and increasing development of the practical application of electricity, it is especially desirable that the general public, both in its character of investor and consumer, should have definite and clear conceptions of the fundamental principles involved in these applications. These Lieutenant Fiske has essayed to furnish in the present volume.

He introduces his subject with an elementary consideration of magnetism, which he follows with a chapter upon statical electricity. The relation of work and potential, and of the different electrical units to each other, is very clearly explained. A chapter is devoted to the laws of currents, and to primary and secondary batteries. In speaking of the electric light, no attempt is made, and very properly, to describe different forms, but to explain the essential principles involved in this class of apparatus. The chapter on electrical measurements is an admirable, concise statement of the subject, as is also that on telegraphy and on the telephone. The chapters upon electro-magnetic induction and upon the dynamo are excellent; but upon the latter Lieutenant Fiske might well have devoted some little attention to the designing of dynamos. He states in his preface that he intended his book to form a bridge between the theory of electricity and its practical application. There is probably no one case in which the practical constructor finds more difficulty in passing from theory to practice than in this of the designing of dynamos. He may know what a unit magnet-pole is and the magnetic effect of a unit-current, but he still is able to but very vaguely see his way to apply this knowledge in determining the size of his field-magnets, the amount and size of wire on them, and the like proportions of his armature, to get the best results. Very few machines, we imagine, have been built so largely by rule of thumb as the dynamo, and therefore information of this sort could not fail of being of great value.

The book closes with a chapter upon the electric railway, giving a general view of the subject, and descriptions of the systems carried out by Siemens Brothers, and that devised by Mr. Edison and S. D. Field.

THE MOUNDS OF THE MISSISSIPPI VALLEY, HISTORICALLY CONSIDERED. By LUCIEN CARR, Peabody Museum. Cambridge, Mass. Pp. 107.

THIS essay, which forms a part of the "Memoirs" of the Kentucky Geological Survey, is an argument in favor of the theory that the mound-builders were the ancestors of the present Indians. The advocates of the theory that the mounds were built by some other race rest to a large extent upon the assumptions that the Indians were not sufficiently advanced to execute the works that have been examined; that they were not agriculturists, as the mound-builders must have been; and that they were not subject to such central authority, or controlled by any such impelling motive, as seems to have been necessary for the construction of such extensive works. Mr. Carr's effort is to controvert these assumptions. He argues, with the aid of many citations from historians, chroniclers, and travelers, that the Indians of the Mississippi Valley lived in fixed villages, which they were in the habit of fortifying by palisades; that they raised corn in large quantities and stored it; that they all worshiped the sun, as the mound-builders are supposed to have done; and that works similar to those of the mound-builders, if not quite as extensive, are known to have been erected by Indians.

A PRACTICAL TREATISE ON MATERIA MEDICA AND THERAPEUTICS. By ROBERTS BARTHOLOW, M. A., M. D., LL. D. Fifth edition, revised and enlarged. New York: D. Appleton & Co. 1884. Pp. 738.

THE appearance of a new edition of this well-known work so soon after the edition of 1881 is due, in part, as the author tells us in his preface, to the recent changes in the "United States Pharmacopœia." Although the work has been adapted to the new official standard in general, we fail to find any reference to the changes in the morphia strength of the opium preparations, and the doses prescribed are the same as in the earlier editions. This is the more to be regretted since the new Pharmacopœia does not itself give any doses.

Many additions demanded by the advance of science have been made in the body of the work, so that nearly one hundred pages in all have been added to the book, making it a complete exponent of the present state of knowledge in this direction.

In Part I the routes by which medicines are introduced into the organism are classified and briefly described. Under this head the author treats insufflation, the use of the nasal douche and atomizers, etc., and gives a valuable chapter upon hypodermatic (hypodermic) methods, with a list of the remedies, solutions, and doses employed, and cautions as to the points to be avoided in hypodermatic injections. Then follows an article on transfusion, with references, as in other cases, to the authorities consulted. In Part II the actions and uses of remedial agents are very fully described. In this part we find the uses of water, externally and internally, of heat, of air, and of massage, discussed, as well as the actions of drugs in general, and the effects of various kinds of aliments and beverages. Formulæ are given for the preparation of animal broths and diet-drinks; the koumiss-cure, whey-cure, and buttermilk-cure, each receive some attention. Directions are also given for the preparation of gruels, jellies, peptonized milk, and other restorative agents.

The various pharmacopœal preparations are briefly mentioned, their strength noted, and the dose given, while their physiological and therapeutical use receives more attention. Processes for their preparation are not given.

In addition to a very copious general index, the work is provided with a very full "clinical index," which will serve to suggest the remedies that may be employed in any particular disease, but which may also prove an injury in other ways as furnishing an aid to quackery, and offering an encouragement to "counter-prescribing" by druggists.

HUMAN PROPORTION AND ANTHROPOMETRY. By Dr. ROBERT FLETCHER. Cambridge, Mass.: Moses King. Pp. 37, with Plates.

THIS is a lecture delivered at the National Museum, Washington, D. C., and includes an examination and explanation of the ancient Egyptian and the Polykleitan canons of proportion, with a review of the results of recent anthropometric measurements.

THE MOTIONS OF FLUIDS AND SOLIDS ON THE EARTH'S SURFACE. By Professor WILLIAM FERREL. Reprinted, with Notes, by FRANK WALDO. Washington: Government Printing-Office. Pp. 51.

THIS essay, the first and most important of the valuable mathematical essays of Professor Ferrel on the motions of the atmosphere, is reprinted as the first part of a paper, the object of which is to place in the hands of the investigator and student the important writings on the subject, elucidated with notes. It is to be followed by a second part, including the writings of several European mathematicians, who have engaged in the study.

METEOROLOGICAL AND PHYSICAL OBSERVATIONS ON THE EAST COAST OF BRITISH NORTH AMERICA. By ORRAY TAFT SHERMAN. Washington: Government Printing-Office. Pp. 202.

THIS volume contains the observations and deductions made by the meteorologist of the scientific party of the schooner Florence, which spent the winter of 1877–'78 in Cumberland Sound, latitude from 64·50° to 67°, and completes the scientific record of the expedition. The observations relate to tidal phenomena, temperature, hygrometry, the winds, atmospheric pressure, the weather, and the color of the sky, cloudiness, precipitation, and auroral phenomena.

ANNUAL REPORT OF THE OPERATIONS OF THE UNITED STATES LIFE-SAVING SERVICE, FOR THE FISCAL YEAR ENDING JUNE 30, 1882. Washington: Government Printing-Office. Pp. 504.

THE report well illustrates the efficiency and usefulness of the service to which it relates. The department has 189 stations, of which 144 are on the Atlantic, 37 on the lakes, seven on the Pacific, and one at the Falls of the Ohio, Louisville, Kentucky. It had cognizance, during the year covered by the present report, of 345 disasters to vessels of different classes, directly involving 2,398 persons. Of these persons, 2,386 were saved, and only twelve were lost. Of $4,766,227 of property involved, $3,106,457 were saved. Interesting statements are made respecting the success that has attended the use of the surf-boat, the self-righting and self-bailing life-boat, the breeches-buoy, the wreck-gun, the heaving-stick, the India-rubber dress, and other life-saving apparatus. Circumstantial accounts are given of each of the cases of shipwreck and rescue; statistics are shown of wrecks and casualties in American waters and disasters to American vessels in other waters, since 1879; and the instructions of the service to mariners in case of shipwreck are furnished.

CHARTS AND TABLES SHOWING GEOGRAPHICAL DISTRIBUTION OF RAINFALL IN THE UNITED STATES. By H. H. C. DUNWOODY. Washington: Government Printing-Office. Pp. 51, with 13 Charts.

THE charts exhibit the geographical distribution of the average monthly and average yearly rainfall in the United States, as determined by observers of the Signal Service. The tables give the actual rainfall occurring during each month at the regular Signal-Service stations and army posts, with the average rainfall for each month, season, and year, and serve to show the fluctuations of rainfall in different sections of the country during the last ten years.

THE NORTH ATLANTIC CYCLONES OF AUGUST, 1883. By Lieutenant W. H. H. SOUTHERLAND, U. S. Navy. Washington: Government Printing-Office. Pp. 22.

THIS report includes the records of the cyclones of August 19th to August 27th, and of August 27th to September 1st, with maps of their course, compiled from the logs of vessels which came under their influence. Nautical directions are appended for manœuvring in, and avoiding the center of, cyclones in the North Atlantic.

HOROLOGICAL AND THERMOMETRIC BUREAU OF YALE COLLEGE OBSERVATORY. Third Annual Report. By LEONARD WALDO. New Haven: Tuttle, Morehouse & Taylor. Pp. 26.

WATCHES continue to be received for testing from a variety of makers, and show a decided improvement in quality of performance. The establishment of a school of horology is suggested, but endowments are wanting. Time-signals are regularly transmitted from the observatory to the railroads of the State. Certificates have been issued of 5,295 thermometers, against 4,552 in 1881–'82 and 1,957 in 1880–'81.

CHEMICAL PROBLEMS, WITH BRIEF STATEMENTS OF THE PRINCIPLES INVOLVED. By JAMES C. FOYE, Ph. D. New York: D. Van Nostrand. Pp. 141. 50 cts.

THE value of problems as means for securing accuracy in a knowledge of the subject, and as tests for attainments, is generally recognized by the best educators. The present work was prepared to meet a need felt by the author, who is a professor in Lawrence University, Wisconsin, in instructing his classes. Its plan is very simple. After defining the terms used, and briefly stating the principle to be illustrated, a typical problem is solved, and from the solution a formula of general application is deduced, which is followed by problems to be worked by the student. These, as a rule, bear upon the fundamental principles of chemistry.

STEAM-HEATING. An Exposition of the American Practice of warming Buildings by Steam. By ROBERT BRIGGS. New York: D. Van Nostrand. Pp. 108. 50 cts.

UNLESS some application of electricity is devised to supersede it, steam is, in all probability, destined to be the agent by which our houses will be heated in the future. Aside from its superior cleanliness as compared with most other methods of heating apartments, the facility with which the warming and ventilation are managed, when it is once established, is a strong recommendation in its favor. Mr. Briggs's treatise includes a great deal that the builder and householder will find useful on the subject, particularly on the practical side.

PUBLICATIONS RECEIVED.

Proceedings of the Boston Society of Natural History. Vol. XXII. November, 1882, to February, 1883. Pp. 112, with Six Plates.

Summary of Progress in Mineralogy in 1883. By H. Carvill Lewis, Philadelphia. Pp. 50.

What shall we do for the Drunkard? By Orpheus Everts, M. D. Cincinnati: Robert Clarke & Co. Pp. 56.

Insects injurious to Vegetation and how to get rid of Them. By Dr. C. A. Greene, of Harrisburg, Pa. Pp. 9.

A Brief Statement of the Doctrines and Philosophy of the Social Labor Movement. By A. J. Starkweather and S. Robert Nilson. San Francisco: S. F. Truth Publishing Company. Pp. 62. 15 cents.

Shall we put Spectacles on Children? By Julian J. Chisholm, M. D., University of Maryland. Pp. 6.

Count Rumford, Originator of the Royal Institution. By Professor Tyndall. London. Pp. 48.

The Batrachia of the Permian Period of North America. By E. D. Cope. Pp. 14.

Paleontological Bulletin. No. 37. Various papers by E. D. Cope. Philadelphia: A. E. Foote, 1223 Belmont Avenue. Pp. 20.

The Evidence for Evolution in the History of the Extinct Mammalia. By E. D. Cope, of Philadelphia. Salem: Salem Press. Pp. 19.

Micrometry, Report of the National Committee, etc. R. H. Ward, Secretary. Troy, N. Y. Pp. 23.

The Bufalini Prize, U. S. Bureau of Education. Washington: Government Printing-Office. Pp. 5.

Development of a Dandelion-Flower. By John M. Coulter. Pp. 7.

The Seasons in Iowa, and a Calendar for 1884. By Gustavus Hinrichs. Iowa City, Iowa. Pp. 24.

Illinois. By William Hosea Ballou. Pp. 6.

Official Register of Dentists in Iowa. Iowa City: A. O. Hunt, D. D. S. Pp. 34.

Pilot Chart of the North Atlantic for January, with a Supplement (pp. 2) giving Position and Detail of Floating Wrecks. By Commander J. R. Bartlett, U. S. Hydrographic Office.

Injurious Garden Insects. By Byron D. Halstead, Sc. D. New York: Phillips & Hunt. Pp. 16. 5 cents.

The Zone of Asteroids and the Ring of Saturn. By Professor Daniel Kirkwood, Bloomington, Indiana. Pp. 4.

People and Places. By Sarah K. Bolton. Cleveland Educational Bureau, Cleveland, Ohio. Pp. 40.

American Society of Microscopists. Proceedings of the Sixth Annual Meeting, August, 1883. Buffalo: Haas & Klein. Pp. 279. $1.30.

Contributions from the Chemical Laboratory of the University of Michigan. Edited by Albert B. Prescott and Victor C. Vaughan. Vol. I, Part II. Ann Arbor, Mich. Pp. 48. 40 cents.

Transactions of the New York Academy of Sciences. "Contents" and "Index" of Vol. I and eight numbers of Vol. II. Pp. 170.

Morphology, Estimates of Intelligence, Vital Chemistry. By Frank B. Scott. Badax, Mich. Pp. 16.

Physical Studies of Lake Tahoe. By Professor John Le Conte. Pp. 37.

Hysteria. By James Hendrie Lloyd, A. M., M. D. Philadelphia. Pp. 21.

Downward Displacement of the Transverse Colon. By Charles Hermon Thomas, M. D. Philadelphia. Pp. 4.

Of Work and Wealth: A Summary of Economics. By R. R. Bowker. New York: Society for Political Education. Pp. 48. 25 cents.

Medical Symbolism. By T. S. Sozinskey, M. D. Philadelphia. Pp. 11.

The Ellipticon. By J. L. Naish. New York. Pp. 2. $1.

New York Post-Graduate Medical School, New York City. Sessions of 1883-'84. Pp. 16.

The Termination of the Nerves in the Kidney. By M. L. Holbrook, M. D. New York City. Pp. 8.

Annual Report of the Hydrographer of the Navy Department. 1883. Washington: Government Printing-Office. Pp. 15.

Report of the Commission to select and locate Parks in New York City. New York: M. H. Brown, 49 Park Place. Pp. 215, with Plates.

Federal Taxation: The Urgent Necessity of Reform. By Samuel Barnett. Atlanta, Ga. Pp. 45.

Prison Contract Labor: Analysis of the Vote (New York). Albany: Weed, Parsons & Co. Pp. 22.

Astronomical Observatory of Harvard College. Thirty-eighth Annual Report. By Edward C. Pickering. Cambridge: John Wilson & Son. Pp. 17.

Bureau of Statistics, Treasury Department. Quarterly Report to September 30, 1883. Washington: Government Printing-Office. Pp. 133.

Physics in Pictures. With Thirty Colored Plates for Ocular Instruction. By Theodore Eckardt and A. H. Keane. London: Edward Stanford. Text, pp. 20. 7*s.* 6*d.*

Common-Sense Binder. New York: Asa L. Shipman's Sons.

Hints on the Drainage and Sewerage of Dwellings. By William Paul Gerhard. New York: William T. Comstock. 1884. Pp. 302. Illustrated. $2.50.

Land and its Rent. By Francis A. Walker, Ph. D., LL. D. Boston: Little, Brown & Co. 1883. Pp. 232. 75 cents.

A Bachelor's Talks about Married Life and Things Adjacent. By William Aikman, D. D. New York: Fowler & Wells. 1884. Pp. 273. $1.50.

The Philosophy of Self-Consciousness. By P. F. Fitzgerald. Cincinnati: E. Clarke & Co. 1883. $1.25.

Electricity, Magnetism, and Electric Telegraphy. By Thomas D. Lockwood. New York: D. Van Nostrand. 1883. Pp. 377.

For Mothers and Daughters: A Manual of Hygiene for Women and the Household. By Mrs. E. G. Cook, M. D. New York: Fowler & Wells. Pp. 292. Illustrated. $1.50.

Geological Survey of Alabama: Report for Years 1881 and 1882. By Eugene Allen Smith, Ph. D. Montgomery, Ala.: W. D. Brown & Co. 1883. Pp. 615, with Maps.

Second Biennial Report State Board of Health of Iowa for Fiscal Period ending June 30, 1883. Des Moines: George E. Roberts. 1883. Pp. 417.

The Relations of Mind and Brain. By Henry Calderwood, LL. D. Second edition. London: Macmillan & Co. 1884. Pp. 527.

Chemistry, Inorganic and Organic, with Experiments. By Charles Loudon Bloxam. From the fifth and revised English edition. Philadelphia: Henry C. Lea's Son & Co. 1883. Pp. 788. Cloth, $3.75; leather, $4.75.

First Registration Report of the State Board of Health of Iowa, for the Year ending October 1, 1881. Des Moines: George E. Roberts. 1883. Pp. 811.

The Field of Disease: A Book of Preventive Medicine. By B. W. Richardson, M. D., F. R. S. Philadelphia: Henry C. Lea's Son & Co. 1884. Pp. 787. Cloth, $4; leather, $5; russia, $5.50.

POPULAR MISCELLANY.

Sub-aerial Decay of Rocks.—Professor T. S. Hunt publishes, in the "American Journal of Science," an elaborate paper on the "Decay of Rocks," in which he insists that recent geological studies afford evidence that a sub-aërial decay both of silicated crystalline and calcareous rocks has taken place universally and from the most ancient epochs, and that it was very extensive in pre-Cambrian times. He further insists that the materials resulting from this decay are preserved *in situ*, in some regions by overlying strata; in others by the position of the decayed material with reference to denuding agents; and that the process of decay, though continuous through later geological ages, has, under ordinary conditions, been insignificant in amount since the glacial period, on account of the relatively short time that has elapsed, and also, probably, on account of changed atmospheric conditions in the later time. The process of decay, he believes, "has furnished the materials for the clays, sands, and iron-oxides from the beginning of Palæozoic time to the present, and also for the corresponding rocks of Eozoic time, which have been formed from the older feldspathic rocks by the partial loss of protoxide bases. The bases thus separated from crystalline silicated rocks have been the source, directly and indirectly, of all limestones and carbonated rocks, and have, moreover, caused profound secular changes in the constitution of the ocean's waters. The decay of sulphureted ores in the Eozoic rocks has given rise to oxidized iron-ores, and also to deposits of rich copper-ores in various geological horizons." Finally, Professor Hunt maintains that "the rounded masses of crystalline rock left in the process of decay constitute not only the bowlders of the drift, but, judging from analogy, the similar masses in conglomerates of various ages, going back to Eozoic time; and that not only the forms of these detached masses, but the outlines of eroded regions of crystalline rocks, were determined by the preceding process of sub-aërial decay of these rocks."

"Colds."—The views of Dr. Page on the subject of "catching cold," published in the "Monthly" for January, having been sharply criticised as unsound and extreme, we give below an extract on the same subject from the London "Lancet," a scientific medical authority of the highest grade: "A person in good health, with fair play, easily resists cold. But when the health flags a little, and liberties are taken with the stomach or the nervous system, a chill is easily taken, and, according to the weak spot of the individual, assumes the form of a cold, or pneumonia, or, it may be, jaundice. Of all causes of 'cold,' probably fatigue is one of the most efficient. A jaded man coming home at night from a long day's work, a growing youth losing two hours' sleep over evening parties two or three times a week, or a young lady heavily 'doing the season,'

young children at this festive season overfed and with a short allowance of sleep, are common instances of the victims of 'cold.' Luxury is favorable to chill-taking; very hot rooms, soft chairs, feather beds, create a sensitiveness that leads to catarrhs. It is not, after all, the 'cold' that is so much to be feared as the antecedent conditions that give the attack a chance of doing harm. Some of the worst 'colds' happen to those who do not leave their house or even their bed, and those who are most invulnerable are often those who are most exposed to changes of temperature, and who by good sleep, cold bathing, and regular habits, preserve the tone of their nervous system and circulation. Probably many chills are contracted at night or at the fag-end of the day, when tired people get the equilibrium of their circulation disturbed by either overheated sitting-rooms or underheated bedrooms and beds. This is especially the case with elderly people. In such cases the mischief is not always done instantaneously, or in a single night. It often takes place insidiously, extending over days or even weeks. It thus appears that 'taking cold' is not by any means a simple result of a lower temperature, but depends largely on personal conditions and habits, affecting especially the nervous and muscular energy of the body."

How and where Malaria thrives.—The health-officers of New Britain, Connecticut, have made an instructive report concerning the prevalence of malarial diseases in that town, and their connection with certain supposed causes. The causes of malarial and other miasmatic diseases are not identical, though they are similar, and the two classes not infrequently occur in a given locality at the same time; and the hygienic measures required to prevent them all are the same. The essential conditions for the development of malaria appear to be: the presence of the malarial germ; a high temperature and dry atmosphere; and favorable conditions of the soil; and the absence of either of them will suspend or prevent the action of the poison. We have power only over the third condition. "A generous rain in the vicinity has, we think, invariably suspended its action. And yet a previous condition of moisture is essential to its manifestation. All deposits of vegetable matter, such as muck, sink-drainage, heaps of decaying vegetable matter, or even wet, spongy land, furnish the essentials for its support; but it is requisite that the soil shall have been very wet, or covered with water some portions of the year." A generous crop of grass, and perhaps of other vegetable substance, has been known to prevent malaria. In 1880 nearly all the families in the neighborhood of some lots which were largely a deposit of muck had malaria. The lots were plowed, dragged, and sowed with grass-seed, and the appearance of the crop of grass and weeds was attended by a disappearance of chills and fever. Two or three other instances are mentioned in the same town, in which fever-and-ague was banished by giving a similar treatment to tracts of swampy and mucky soil. Another case is specified where malaria was prevented by the drying up of the sewerage and sink-water which usually found its outlet through a system of ditches cut in muck. Preparations were making to lay tiles in the ditches and fill them up, but, before this was done, a heavy rain washed them out, and "caused the prevailing sickness to abate as suddenly as it had commenced." From the first, malaria has not prevailed in those parts of the city where vegetable deposits and filth have been absent, and the health of the streets in which sewers have been laid has been remarkably good.

Can Dogs be taught to read?—Under the title "Instinct," Sir John Lubbock writes as follows in a recent number of the "Spectator":

"SIR: Mr. Darwin's 'Notes on Instinct,' recently published by my friend Mr. Romanes, have again called attention to the interesting subject of instinct in animals. Miss Martineau once remarked that, considering how long we have lived in close association with animals, it is astonishing how little we know about them, and especially about their mental condition. This applies with especial force to our domestic animals, and above all, of course, to dogs. I believe that it arises very much from the fact that hitherto we have tried to teach animals, rather than to learn from them—

to convey our ideas to them, rather than to devise any language, or code of signals, by means of which they might communicate theirs to us. No doubt, the former process is interesting and instructive, but it does not carry us very far. Under these circumstances, it has occurred to me whether some such system as that followed by deaf-mutes, and especially by Dr. Howe with Laura Bridgman, might not prove very instructive, if adapted to the case of dogs. Accordingly I prepared some pieces of stout cardboard, and printed on each in legible letters a word, such as 'food,' 'bone,' 'out,' etc. I then began training a black poodle, 'Van' by name, kindly given me by my friend Mr. Nickalls. I commenced by giving the dog food in a saucer, over which I laid the card on which was the word 'food,' placing also by the side an empty saucer, covered by a plain card. 'Van' soon learned to distinguish between the two, and the next stage was to teach him to bring me the card; this he now does, and hands it to me quite prettily, and I then give him a bone, or a little food, or take him out, according to the card brought. He still brings sometimes a plain card, in which case I point out his error, and he then takes it back and changes it. This, however, does not often happen. Yesterday morning, for instance, he brought me the card with 'food' on it nine times in succession, selecting it from among other plain cards, though I changed the relative position every time. No one who sees him can doubt that he understands the act of bringing the card with the word 'food' on it, as a request for something to eat, and that he distinguishes between it and a plain card. I also believe that he distinguishes, for instance, between the card with the word 'food' on it and the card with 'out' on it. This, then, seems to open up a method which may be carried much further, for it is obvious that the cards may be multiplied, and the dog thus enabled to communicate freely with us. I have as yet, I know, made only a very small beginning, and hope to carry the experiment much further, but my object in troubling you with this letter is twofold. In the first place, I trust that some of your readers may be able and willing to suggest extensions or improvements of the idea. Secondly, my spare time is small, and liable to many interruptions; and animals also, we know, differ greatly from one another. Now, many of your readers have favorite dogs, and I would express a hope that some of them may be disposed to study them in the manner indicated. The observations, even though negative, would be interesting; but I confess I hope that some positive results might follow, which would enable us to obtain a more correct insight into the minds of animals than we have yet acquired."

Salts in Rivers and in the Sea.—The sea, it is well understood, is fed with salt as well as with water, by the rivers. The question then arises naturally, How is it that the rivers—admitting that they are mildly salt, although they appear to be fresh—differ from the ocean in the kind as well as in the strength of their saltness? Mr. W. Matieu Williams answers the question by showing that, when sea-water is evaporated, sulphate of lime is the first salt to be deposited, while chloride of sodium, sulphate of magnesia, chloride of potassium, and the bromides, are deposited later. Hence, when the sea-water reaches the point of saturation with sulphate of lime, no more can be dissolved in it, but all additional supplies must be deposited. Moreover, if a soluble salt of lime were brought into the sea, its lime would combine with the sulphuric acid there combined with magnesia, or soda, or potash, which would, in obedience to a curious chemical law, leave those bases to combine with that one which would form an insoluble compound. Thus the total quantity of lime in sea-water is limited by the solubility of sulphate of lime, and this amounts to only about one part in four hundred of water.

The Caribs and the Greeks.—Mr. A. J. Van Koolnijk has published in the "Journal of the Dutch Geographical Society" an account of Carib tombs and relics which have been found in the Island of Aruba, off Dutch Guiana. Among the relics are potteries of good workmanship, elaborately ornamented and painted in a variety of colors obtained on the island. Some of the more common ornaments are figures of frogs and frogs' heads, which indicate that the Indians had

considerable respect for those animals. Many of the ornaments, the handles of the vessels, and the skill with which the reliefs were finished, reminded the discoverers of Greek patterns. Some of the vessels, too, bore figures which were thought to be inscriptions or hieroglyphics, and a remarkable resemblance was traced between these characters and the letters of the Greek alphabet. This leads our Dutch antiquary to consider the question whether there may not have been some kind of a connection between these Caribs and the ancient Greeks. Ch. Rümelin is quoted as having suggested the possibility of looking for the origin of the northern tribes of Colombia, through the Guanches of the Canary Islands, to the Foulahs of the Soodan. Cyries also speaks of having seen hieroglyphic figures representing the sun, moon, and various animals, roughly cut on the granite rocks of Guiana at such heights that ladders had to be used to reach them.

The Stone Age in Africa.—Herr Richard Andree has accumulated a large mass of evidences of the existence of a stone age in Africa—a point which has hitherto been involved in much doubt. The Djurs, on the White Nile, still hammer their iron with a block of granite; smoothed stones are still used for hammer and anvil between the east coast and the Tanganyika Lake; the Hottentots and Bushmen dig roots with perforated stones; the Arabs in Egypt curry their shorn sheep with flint; the Bushmen tip their arrows with bone, and the Gabiri, in Bagirmi, with clay. Stories, which are reminiscences of the days of stone instruments, are told among the Hereros, and among the Bazimba of Madagascar. When the Europeans discovered the Canary Islands, they found the Guanches in the midst of a stone age. This much we know of the present use of stone. The historical evidences are scarce. Diodorus Siculus says the Libyans threw stones at their enemies, and Agatharcides says that the Ethiopians tied stone points to their arrows, while Strabo says they tipped them with antelope-horn. Vessels and implements of stone have become quite common among the "finds" of Egypt, and in all the countries and the deserts to the western border of Morocco. While not more is known about the stone evidences than about the other features of the intermediate countries, flints and stone vessels, of both crude palæolithic and more highly-finished forms are found at numerous places in the southern point of Africa, from the mouth of the Orange River to Delagoa Bay. The implements are very similar in form and material to the European finds, and present the same puzzle in the occurrence of nephrite among them. Assuming that evidences will be found at least as abundantly in the countries which have not yet been examined for them, the conclusion is drawn that the Africans, although they have been using iron as far back in historical times as our knowledge extends, had also a stone age.

Indistinctness of Race Divisions.—Professor Léon Rosny, in his forthcoming work on the "Danubian Principalities," says, speaking of the nationality of the Roumanians, that that people confirms a view which he has held for years, and which is also M. Renan's view, that the matter of nationality is very largely a question of feeling. Many different elements may have contributed to the formation of a Roumanian nationality, but the chief one has been the fancy that the people of Moldavia and Wallachia were descended from a mixture of the ancient Dacians with Trajan's soldiers, and were, therefore, the Romans of the East, whose mission it was to guard the interests of the Latin race in that part of Europe. Reminiscences of Roman antiquity are still current in the country, as, for example, in a popular dance, the Kalusar, which represents the rape of the Sabine women. Conversely, the Tartars of the Dobrudja are composed of a great variety of types, from that of the pure European to that of the most pronounced Mongolian, but they all pass alike for Tartars. These things suggest, again and again, the thought that the characteristic traits which are held to be most decisive in determining the differences between the groups of mankind are in reality very flexible and changeable. Physical tokens are of service only for the establishment of two or three grand divisions among men, and the value even of these divisions is becoming more and more subject to criticism. Linguistic

distinctions, on which ethnographic classifications have for some time been assumed, are likewise very fallacious. People have been capable of changing their vocabulary and their grammar, and even of discarding their whole language and adopting another of different spirit. The groups of the human race are, as a whole, the product of historical changes in the different phases of their existence, and the influence of the surroundings in which they have developed themselves. Professor Halévy supports M. Rosny's theory, and believes that nations may change their language, their disposition, and their moral character, according to the surroundings among which they live, and according to their institutions. Africans, for example, show a change from the moment they become Mohammedans. The word "race" should no longer be used in ethnology. "When I was in Abyssinia," he says, "during the war between England and King Theodore, it was quite impossible to distinguish a Hindoo in the British service, when he was stripped, from a native Abyssinian. Even Theophrastus was aware of the striking similarity, and classed the Indians and Abyssinians together as Ethiopians."

The Check in the Growth of France.—The attention of French economists has been drawn for several years to the fact that the population of their country is not increasing, but shows rather a tendency, in many parts of the country, to diminish. The tendency is steadily manifested, in several departments, to a greater degree than in others, and has been maintained with considerable uniformity in those departments where it is most marked. The departments in which the decrease is most observable are the group in Languedoc and the group in Normandy. Of the five Norman departments, only one, that of the Lower Seine, shows an increase, and the increase there is solely due to the attraction of the large towns of Havre and Rouen. The tendency of population to gravitate toward the cities, at the expense of the rural districts, is as marked in France as in other countries, and contributes its quota toward retarding the growth of the country as a whole; for mankind are less prolific in towns than in the country. A few departments show an increase of population, and these, curiously, are about evenly divided between the richest and the poorest departments in the nation. The cause of the stationary condition of the population is found, by those who endeavor to account for it, in the evenly comfortable situation of the people. They are contented with things as they are, and avoid having large families, in order to evade extra exertion and prevent the diminution of their estates that would follow if there were many heirs to divide them among. Every one aims to live and save, so as to leave his children as well off as himself, and a little better off if possible. Hence very few have more than three children. All the large towns have increased enormously during the present century, at such a rate that, if the population of the whole country had increased at the same rate, France would have had seventy-five million inhabitants, or would have been as densely populated as England. Had it not been, in fact, for the augmentation of the populations of Paris, Lyons, and Marseilles, the population of all France would have actually diminished during the last five years. This augmentative population, except as it is of foreign origin, contributes, as we have seen, to the tendency to depletion of the aggregate.

Anthropology in Italy.—Anthropology is studied in Italy with considerable zeal, and nearly every large town has its collection and its specialist of repute. The country, as may be judged from the figure it has made in history, is rich in monuments dating from a very great antiquity. In upper Italy earth-walls have recently been discovered on the mountain-heights, which are attributed to the Celts. The plains of Lombardy and Emilia have furnished numerous remains of lake-dwellings, which have been studied by Pigorini, Strobel, and Chierici, and are represented in the collections of Parma and Reggio. Not less important are the Etruscan necropolis of Margabotto and that of the Certosa of Bologna. Bologna has its newly built *Museo Civico* under the direction of Gozzodini, and the accomplished geologist Capelini, who has discovered traces of cannibalism in a cave on the Island of Palmaria. The Olmo skull, which Cocchi

regards as post-Pliocene, and which may be compared with the Cro-Magnon and Steeten skulls, is in the geological collection of this city. Mantegazza has founded an anthropological and ethnological museum in Florence, with Miloni in charge of the Etruscan and Schiaparelli of the archæological departments. Perugia, too, has Etruscan antiquities, and Belluci is collecting prehistoric stone implements there. Pigorini has established a prehistorical and ethnological museum at Rome, where Michael St. de Rossi has won much honor by his researches. Nicolucci, who has founded an anthropological collection at the University of Naples, has examined about a hundred skulls, and has found them to be meso-cephalic Grecian skulls, very like those still typical in the region.

Two East African Tribes.—Some interesting information respecting East African tribes has been obtained by the London Geographical Society from the notes of the Rev. T. Wakefield, missionary at Ribé, near Mombasa. Kavirondo appears to be the most important country on the eastern shore of the Victoria Nyanza, and is described as a great grass-clad plain, with a few detached hills and clumps of trees, but altogether without forests. The people are tall and powerfully built, of a deep black, and with thick lips and flat noses. They wear their hair short, or dress it elaborately, or shave it all off but a tuft on the crown, or shave half the head, or a few patches only, according to their taste. The women tattoo the stomach and the back, but the men do so only rarely. Dress is almost unknown. The women are content with a string worn round the waist, to which they attach a tail-like appendage made of bark. They wear no ornaments, but smear themselves with disagreeable (to whites) substances. The men wear iron bracelets on their fore-arms, and above their elbows. Their spears are long and have short blades, and their shields are made of buffalo-hides. Neither swords nor knives are in use. Both sexes work in the fields. Millet, beans, bananas, and large crops of sweet-potatoes are grown, and two harvests are gathered in the year. A thick porridge, on festive occasions, made with milk, constitutes the staple food, and is eaten with the hands. Cattle, sheep, and goats are raised. The huts are circular and roomy, and high enough for a man to stand upright within them. Another people, the Wa-Ukara, are likewise tall and muscular, and have a similar variety of tastes about their hair, They paint their bodies red, with clay mixed in oil, and their arms and legs with white; tattoo their stomachs and upper arms and have few ornaments. Women wear kilts of bark-cloth and skins, and men a longer garment of like material. They live in circular huts, built over pits three feet deep, and covered with conical roofs. They marry only when full-grown, and pay the dowry for their wives in cattle and goats. They grow a variety of crops, and pound their corn or millet in a wooden mortar, or grind it on a flat stone, beneath which a cowhide is spread out to receive the flour. Their domestic animals are cattle, goats, sheep of a superior kind, dogs, and fowls, but cats are not known. Their blacksmiths manufacture hoes, axes, and spears; and they produce cooking-pots of clay and baskets of wicker-work. Ukara contains a large number of populous villages.

NOTES.

Near Mandan, in the neighborhood of the junction of the Hart and Missouri Rivers, are what appear to be two large cemeteries of an ancient race. One of them is composed of what are described as trenches filled with bones of man and beast, and covered with several feet of earth so as to form considerable mounds. With the bones are associated broken pottery, vases of flint, and agates. The pottery is described as being of a dark material, handsomely decorated, delicate in finish, and very light, pointing to the existence of a considerable degree of civilization.

The death has been announced of Mr. Robert B. Tolles, of Boston, the distinguished maker of American microscopes and telescopes of great powers.

Dr. Grassi is said to have made the important discovery that flies are active agents in the propagation of disease. They take the ova of parasitical worms into their mouths and discharge them unchanged in convenient places, often upon substances to be used as human food. Dr. Grassi is so deeply impressed with the magnitude and seriousness of the consequences that he hopes some effectual means may soon be found of destroying flies.—*Science Monthly.*

SPECIAL attention is given by the British Government officers, in Cyprus, to the destruction of the locusts, with a view to their extermination. The governor reports that in 1882 he was successful in keeping the pests down, and he considers the method of screens so effectual that he proposes to rely on catching the live locusts, and not to gather their eggs. The accepted practice in China, Russia, and Turkey is based on a different view.

BRIGADIER-GENERAL ANDREW A. HUMPHREYS, who died in Washington on the 28th of November, in the seventy-fourth year of his age, performed many important services in the shape of scientific surveys and works of engineering. He was Superintendent of the Coast Survey from 1844 to 1849, of the Topographic and Hydrographic Survey of the Mississippi Delta from 1849 to 1851, and of surveys for railroads and geographical explorations west of the Mississippi to 1861. He was again engaged in the examination of the Mississippi levees for about a year after the war, after which he was placed in command of the Corps of Engineers and in charge of the Engineer Bureau. The report on the "Physics and Hydraulics of the Mississippi," prepared by him in conjunction with Lieutenant H. L. Abbott, has much scientific value.

M. DE SARZEC, a French Oriental archæologist, suggested some time ago that the ancient Eastern stone-cutters used diamond-pointed tools in their more delicate work on diorite and other hard stones. He is corroborated by Mr. Flinders Petrie, an English Egyptologist, who has found in his minute examinations of ancient work lines of a character that could not apparently have been cut in those stones (diorites and granites) with any metallic tool, but must have been made with a gem-point.

M. ROBERT HAENSEL, of Reichenberg, Bohemia, has succeeded in accurately photographing a flash of lightning. His pictures, of which he has taken several, show the light of the flash under the form of long-continuous sparks, traversing the atmosphere. In one of them the point where the spark meets the earth is very clearly defined. With the spark, the landscape also is well produced, and a means is given for estimating the length of the luminous train, which, in one instance, is calculated to be 1,700 metres, or more than a mile.

AN International Society of Electricians has been formed at Paris, under the honorary presidency of M. Cochet. It is open for admission to membership to every Frenchman or foreigner interested, whether in a general, scientific, industrial, or commercial way, in the progress of theoretical or applied electricity. The price of membership is twenty francs, or about four dollars, a year.

M. GEORGE BONTEMPS, a French chemist, distinguished particularly for his labors in the application of the sciences to glass-making, died at Amboise, France, November 14th, aged eighty-four years. He began his chemical studies under Gay-Lussac and Thenard, and has been connected with glass-making, in nearly every branch of which he has participated, since 1818. He introduced several improvements in the art, among them the revival of the manufacture of ruby glass in 1826, after it had ceased for two centuries, and was successful in making good optical glass. He published many papers related to glass-making, and a large work on the subject.

M. DE QUATREFAGES recently presented to the French Academy of Sciences a report by M. E. Cartailhac on a flint-quarry that was worked during the stone age at Mur-de-Barrez, in Aveyron. It consisted of vertical pits dug through the Aquitanian limestone to the level of the flint-beds, at depths of from two to four metres. The walls of the pits bore evident marks of the pick, a tool of deer-horn, of which a considerable number of specimens were found in the bottoms of the pits. These pits are the first that have been found in France, and are very much like the ones which have been discovered at Spiennes, in Belgium, and Cisbury, in England.

M. IVON VILLARCEAU, a French astronomer and mathematician, died on the 23d of December, aged seventy-one years. He was educated to be an engineer, but became connected with the observatory, where he distinguished himself by his investigations of the periodicity of comets, his calculations of the motions of the stars, and his services in determining latitudes and longitudes.

THE common objection among womankind, says the "Pall Mall Budget," to letting their ages be known is not shared by the ladies of Japan, who actually display the facts as to their age in the arrangement of their hair. Girls from nine to fifteen wear their hair interlaced with red crape, describing a half-circle round the head, the forehead being left free with a curl at each side. From fifteen to thirty the hair is dressed very high on the forehead, and put up at the back in the shape of a fan or butterfly, with interlacings of silver cord and a decoration of colored balls. Beyond thirty, a woman twists her hair round a shell-pin, placed horizontally at the back of the head. Widows also designate themselves, and whether or not they desire to marry again.

THE subject fixed for the Howard medal, to be awarded next year by the English Statistical Society, is "The Preservation of Health, as it is affected by Personal Habits, such as Cleanliness, Temperance, etc."

AUGUSTUS WILLIAM HOFMANN.